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Ores and industry in the Far East

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RESEARCH PUBLICATIONS OF THE COUNCIL ON FOREIGN RELATIONS

ORES AND INDUSTRY IN THE FAR EAST

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The Influence of Key Mineral Resources on the Development of Oriental Civilization

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PREFACE

It is often assumed that when China becomes aroused to the need of equipping herself with the tools and technique of America and Europe, there will be a great and rapid industrial and commercial advance comparable with that of England, Germany, and the United States during the last century. Her supposed untold wealth, in "vast resources" of raw materials and man power, when organized, is to produce, we are told, both the fiercest industrial competition the world has ever seen and the greatest potential market. The Industrial Revolution of the West, it is forebodingly asserted, is only the curtain-raiser for the vaster drama of the twentieth century to be played in Asia, where "the stage seems set for catastrophe."

The Industrial Revolution has not been mis-named. It is one of the major movements in the history of Western civilization, and the countries which have led the way have experienced, historically speaking, an extraordinarily rapid transformation. At the centre of the Revolution is a new invention in industrial organization, the institution of the factory system, still in process of evolution. For this as for all such momentous changes, however, a long preparation has been required; a pre-adjustment of social values has been as essential as the accompanying readjustment. The spread of the new economic institutions, from England to the western continent of Europe and thence more haltingly to Spain and Italy and eastward to the Slavic countries, and their migration westward across the Atlantic, have been conditioned not only by institutional and psychological factors but also by factors of economic resources and commercial geography. The Industrial Revolution has met hindrances in the West, but it has found and will find much greater restraints in Asia, where ancient civilizations present social institutions and religious beliefs deeply imbedded

and hostile to change. Inhibitions of this nature, as well as the economic difficulties, have been described by many competent observers in the Far East, most recently and fully in the special inquiry made in 1924 by the British consuls in China. One of the most interesting of these reports sums up the forces there working for and against modernization, and draws an historical parallel: "If this generation can raise the average level of China to the English average of 1450 or 1500 it will not have done badly."

Despite the recognition of cultural difficulties as an impediment to the rapid diffusion of Western industrialism, there has remained a fixed and general belief in the ultimate, if not immediate, effects of the supposed vast material resources of China, and especially of her potential mineral wealth. It was therefore with surprise, not unmixed with incredulity, that we have lately heard this belief challenged. The experts have announced, as the result of repeated explorations, that the Far East, estimated by Western standards, is seriously deficient in some of the most important minerals, and especially in iron, the basic metal of our civilization. Professor C. K. Leith in 1925, at the Williamstown Institute of Politics, and in his subsequent article in "Foreign Affairs" (April, 1926), set forth this conclusion of the mining engineers and indicated some of the consequences of so vital a defect in the equipment of the Western Pacific region. One of the conference groups of the Council on Foreign Relations, that on the Far East conducted by Mr. H. Foster Bain, devoted its sessions of 1925-26 to an examination of this subject. It is clear that the evidence for the view as to the serious paucity of Far Eastern mineral resources rests on a series of careful technical studies made by highly qualified mining engineers and geologists. Since it is also apparent that their findings are of fundamental importance, as affecting the whole problem of Far Eastern development, and therefore should be more generally known, the Council on Foreign Relations has requested Mr. Bain, a recognized authority, to prepare, as the first of its Research Publications, the present compact volume on the mineral resources of the Far East. Mr.

Bain and a well-equipped staff of experts had made extended field investigations in China and an elaborate report for the New York Orient Mines Company. Together with all the published material, Mr. Bain, in writing this book for the Council, has drawn upon the unpublished report. In permitting its utilization the Orient Mines Company has rendered a public service which the Council on Foreign Relations gratefully recognizes.

In the illuminating survey, herewith presented, the varying mineral resources of China, Japan, Eastern Siberia, Indo-China, Siam, the Netherlands East Indies, the Federated Malay States, and the Philippines are examined. To China's coal, antimony and tungsten, two of the other countries add tin, and these complete the list of really considerable mineral supplies. None of the countries bordering the Western Pacific Ocean shows resources of iron ore, actual or potential, which in quantity or quality range with the great deposits of the Atlantic area. Nor are the other leading metals, copper, lead, zinc, or even gold and silver, likely to come from the Western Pacific region in quantities comparable with those an industrial civilization has elsewhere found. India, not included in this survey, is the one great Asiatic country which possesses large iron ore resources, but it is doubtful if her supply of coking-coal is adequate for the great scale of production required in a modern iron and steel industry. What is dubious for India is apparently certain for China and Japan. They cannot, from their own or from readily-imported supplies of iron ore, build up the dominant industries which have formed the central core of the recent economic history we have known. Their supplies, indeed, are sufficient for the modest requirements of the immediate future, but they are entirely inadequate for the full growth of an Industrial Revolution of the type and stature the West has acceleratingly shown in the industrial growth of England, Germany, and the United States. The factory system, especially for the production of textiles, has found lodgment, but only as a minor element, in the economic structure of India and Japan; it is in the stage of earliest beginnings in China; but its further expansion will

probably be retarded or modified by the limitation of domestic iron supplies.

No modern country can be self-sufficient, but, with this serious limiting factor, least of all can the countries of the Far East, as they become modernized, be economically independent. Their growing nationalism—an inevitable and desirable development—may find bounds set, both for peace and war, by multifarious needs for railroads, steamers, machine-equipment, which can be satisfied in their fuller extent only by importation and the resulting ever-closer international relationships. Gradually developing those manufactures which can be exchanged for the essential metal products, and struggling with an even more difficult food problem, the countries of the Far East must, it would seem, become steadily more dependent upon those regions which are technically more advanced and in minerals much richer.

EDWIN F. GAY

CONTENTS

LIST OF ILLUSTRATIONS

ORES AND INDUSTRY IN THE FAR EAST

CHAPTER I

INTRODUCTION

THE fabled riches of the East have attracted adventurers since the beginning of written history. It was the desire to participate in the trade with the Far East, or to gain a larger share of it, that led to the discovery of South Africa and the Americas, to the conquest of India, and to the forcible opening of China and Japan. It was the same motive that led in our own days to the cutting of the Suez and Panama Canals and to the political piracies through which the Orientals have come most frequently to know us of the Occident. From the first the Far East has stood to the Westerner for silks, spices, jewels, and other luxuries; and since these were the main products derived from the region, it was lightly assumed that they were, in fact, its main products, and hence, by easy transition, that they must be common in it.

A little reflection on the distances and risks involved in trade would have forced recognition of the fact that it is only the rare and therefore precious articles that can be exported where the cost of transport is as high as that from the Orient has long been. The Far Eastern countries are, in fact, poor rather than rich, and their peoples neither possess nor are they even familiar with luxuries to a degree common in Europe and America. Thus, the first premise upon which the West has built up its notion of the East is faulty. The amount of luxuries and comforts per capita is limited both in the regions and districts of sparse and of dense population; and it therefore reflects a true, and not merely an apparent condition of scarcity. As compared with equal areas of either Europe or America, the great

stretches of Asia do not have equal resources either developed or undeveloped.

Belief in the richness of the East is, nevertheless, firmly held throughout the world and is a powerful factor in shaping the political and commercial policies of most nations. It is true that in recent years it has become customary to dilate more upon the potential than the present richness of the Far East and to formulate trade policies more with a view to returns anticipated at some hazy period in the future than in time to be included in the next trial balance. That trade with the Far East will increase may be reasonably anticipated, and out of it profits will be made; but there are excellent reasons for discounting the rosy predictions that have been common in recent years.

In considering trade prospects it is necessary to keep in mind the truism that buying power is limited to selling power, a fact recently driven home to us by experience in Europe. It is not merely necessary to teach the Oriental more wants; he must also be shown where to find the goods with which to pay for what it is proposed to sell to him. Trade rests on exchange of commodities, and this is as true in China as in Chicago. Unless it be on this basis it cannot long continue.

If, then, we of the West are to realize even part of our rose-colored dreams of expanding Oriental trade, it becomes necessary to determine what sources of untapped wealth exist there and how to bring them into use to pay for the machinery, clothing, and general manufactures which we wish to sell. This is all the more necessary since there is much reason to believe that desire to buy, in China at least, has already outrun ability to pay. A Chinese now appreciates fully the superiority of his foreign neighbor's tools and will walk a long distance to borrow an American saw in preference to using the clumsier native article. But to buy a similar saw involves an incursion into realms of higher finance that is in many instances entirely beyond him. The amount of telegraphing that a Chinese official will do when he has a frank is no whit less than that of an American politician, and it is only the cost of the tolls that keeps those without franks from equally liberal indulgence.

It is not merely lack of desire to purchase but chiefly lack of money to pay which limits sales in the East. To realize the world's announced ambition for a larger trade with the Far East it will be necessary to wage a campaign of education designed to increase not only demand for foreign, but also production of native goods.

In determining the possibilities in this direction it is advisable first to get a clear picture of the resources of the countries involved and the conditions limiting their development. In doing this the facts as regards China may be used to illuminate the situation. That country is large, has varied resources, is populated by intelligent, industrious people, and is not as yet developed to any great degree along modern lines. Japan has gone further in the change from a civilization based on agriculture and household industries to modern specialization and integration in large units. Other nations of the Far East have perhaps gone less far. China may, for purposes of this discussion, be treated as a "grab sample" of presumably average composition and as such made the basis of a first analysis of our problem.

The only trial balance of China's trade as a whole that I have seen, was prepared in 1909 by Thomas Ainscough, an especially able and careful British Trade Commissioner, and while the war has brought about many changes I believe it still affords an excellent insight. Both exports and imports have since increased. Payment of the Boxer indemnity to certain countries has ceased and to others it is deferred. But foreign borrowings are larger and other compensating changes have come in. For present purposes it will probably be more helpful to study the figures of a period sufficiently far back to afford a perspective rather than to attempt analysis of the confusing statistics of later but abnormal times. Without therefore concerning ourselves closely wtih actual figures, I may mention that Ainscough's data show that the nominal trade balance had, when he made his studies, been against China for many years. In addition China had, since Boxer days especially, been compelled to make heavy annual indemnity payments abroad. Because most of the foreign, and much of the

local, trade of the treaty ports is handled by foreign firms, there has also been a stream of dividends and profits flowing out of the country.

In the face of these figures the situation from the Chinese standpoint would seem bad, but further examination shows some compensations. For example, the total profits remitted home by foreigners in the year taken amounted to less than the sums spent in China by foreigners for maintenance of garrisons, war vessels, and the merchant vessels used in local trade. Similarly, foreign travelers and tourists, even in 1909, spent more in China than the cost of ocean freight and insurance paid to foreign steamship companies. For the amount that the foreign governments expended in China on embassies, consulates, and similar activities, the Chinese were able to maintain their own embassies abroad, to pay the expenses of their travelers and tourists, to keep many students in foreign universities, and still to have a small credit. The balance against China in specie trade was just about countered by the sums spent by missionaries in upkeep of schools, hospitals, churches, and similar activities. The cost of munitions imported was met by a favorable balance of frontier trade overland. The large sums sent abroad in payment of principal and interest on loans and of installments on various indemnities, amounted to less than the total earned and remitted home by Chinese living abroad.

When all these facts are taken into account the situation from a Chinese point of view is more hopeful. The actual net balance for the year favorable to the foreigner did not then represent money which he was able to carry away, but sums reinvested in China, and since then remittances on account of foreign loans have largely ceased. No more here than anywhere else will business grow without increases in capital and it is necessary always to turn back into industry a considerable part of the nominal profits. China pays for her purchases with goods and services, and if to the exports be added the sums sent home by Chinese living abroad the balance of trade nearly disappears. If to this be added the amount paid for repairs in China for foreign ships, which constitutes a further service sold to foreigners, the

balance is the other way. Foreigners are steadily increasing their equity in the country but except for the various indemnities levied against China the increase would have been much less than it now appears.

C. F. Remer has made a study of the foreign trade of China and has presented less complete balances for several periods from 1871 on. His figures for the years 1914 to 1921 inclusive are as given below:

CHINA'S BALANCE OF INTERNATIONAL PAYMENTS, 1914-1921[1]
In Millions of Haikwan Taels

	Debits	*Credits*
Excess of merchandise imports	980	..
Net import of silver	120	..
Payments of interest and principal on loans and indemnities	250	..
Net export of gold	..	11
Proceeds of new loans	..	350
Emigrants' remittances	..	640
Investments by foreign individuals and corporations	..	100
	1,350	1,101

The actual foreign trade of China, considering only the larger items, is shown in the following tables of exports and imports:

PRINCIPAL EXPORTS OF CHINESE MERCHANDISE IN 1925
Includes all commodities having a total value of $5,000,000 or over; in thousands of U. S. gold dollars; conversion rate, Haikwan tael equals $0.84; source: Chinese Maritime Customs.

Silk and silk products	$151,630
Beans and beancake	100,954
Vegetable oils	39,020
Eggs and egg products	27,730
Cotton, raw	25,069
Tea	18,601
Tobacco and cigarettes	17,985
Coal	16,811
Nuts	15,768
Hides and skins	14,163
Wool	13,990
Cotton, cloth and yarn	12,112
Tin slabs	10,134
Furs	9,928
Seeds and seed cake	9,513
Meat and meat products	9,605
Bristles	8,027
Bran	5,475
Carpets	5,344
Total Exports	$652,136

1 "The Foreign Trade of China," p. 225. Shanghai, 1926.

PRINCIPAL IMPORTS INTO CHINA IN 1925

Includes all commodities having a total value of $5,000,000 or over; in thousands of U. S. gold dollars; conversion rate, Haikwan tael equals $0.84; source: Chinese Maritime Customs.

Cotton and cotton manufactures	$223,496
Sugar	71,452
Mineral oils	59,439
Rice	51,275
Metal and manufactures	48,504
Tobacco and tobacco products	33,370
Coal	21,907
Fish and fish products	21,421
Dyes, paints and varnishes	19,159
Wheat and wheat flour	14,749
Machinery	13,323
Wool and woolen goods	13,270
Chemical products including medicine	12,190
Leather and leather goods	8,849
Lumber	7,542
Electric machinery and equipment	7,313
Bags	6,564
Railway materials and supplies, excluding rails	6,441
Total Imports	$796,206

In considering such figures it is to be remembered that much trade between north and south China is conducted through the port of Hong Kong, which is leased to the British, so that the trade through it is classified as foreign though in fact essentially coastal.

It will be noted that the country is even now a heavy importer of mineral products and of machinery and supplies made of metals. Of coal, it both exports and imports. In 1923, it sent out 3,108,682 tons and received 1,366,108. Ores and metals are exported as shown by the following figures for 1925, the values having been converted to gold dollars on the basis of 84 cents for one Haikwan tael, and the figures being taken from the reports of the Chinese Maritime Customs.

EXPORTS OF METAL AND ORES FROM CHINA IN 1925

Tin	$10,134,000
Iron ore and pig iron	4,568,000
Antimony	4,212,000
Tungsten ores	939,000
Zinc ores	336,000

The primary sources of wealth, as is well known, are agriculture (including forestry and animal husbandry), fisheries and mining. In the first of these the Chinese have long been held to excel and the diligence and acumen of Chinese farmers have been cited as examples to all the rest of the world time and again.[1] Without attempting to pose as an expert one may doubt whether the millennium in agriculture has been quite reached even in China. The subject is too large for discussion at this time,[2] but my own belief is that opportunity exists for greatly broadening the field of Chinese agriculture and increasing food production. In these days when so large a portion of the population of Western countries is crowding into the cities and leaving the farms it is worth serious thought that in China, and indeed in the Far East generally, there is an enormous population of industrious frugal people who prefer farming. The possibilities of drawing on the East for a much larger portion of the world's food supplies are too great and too important to warrant indifference. Food and other agricultural products may well in time form its chief exports.

In a recent instructive book,[3] Frank J. Goodnow, president of Johns Hopkins University, and formerly adviser to the Chinese Government, referred to Chinese civilization as a "vegetable" civilization,[4] meaning thereby that the Chinese depend mainly upon the plant world for food, clothing and other necessities and luxuries. The same characterization could with nearly equal justice be made of Oriental civilizations in general. Even the animal world is not so largely drawn upon for food as in the West owing to sentimental objections to eating beef and the widespread belief in the transmigration of the soul and consequent disinclination to kill cattle. This is not, it is true, the whole story; the Chinese at least have convinced themselves that more babies can be raised per acre by devoting the land to cultivation of food for direct consumption by human beings, than by adopting the indirect cycle of feeding first to cattle. In this they perhaps undervalue the ability of animals to

1 See especially: F. H. King, "Farmers of Forty Centuries." Madison, Wis., 1911.
2 It is to be made the subject of further study by the Far Eastern conference group of the Council on Foreign Relations.
3 F. J. Goodnow, "China, An Analysis." Johns Hopkins Press, Baltimore, 1926.
4 Op. cit., p. 43.

use as food rough vegetation not suitable to human consumption. However that may be, animals are not as widely used for food as in the West, and Eastern peoples do in fact depend mainly upon the plant kingdom for food, clothing and implements. A limited amount of metal is used in tools and, in China particularly, houses are generally made of stone or soft burned brick. Such heavy drafts have already been made through the centuries on the forests that it is common to see a limestone slab used to span a ditch where a board would be employed in America. Stone is substituted for wood in many other uses. Except, however, for this forced use of stone in lieu of wood, the Chinese depend mainly on the plant kingdom, even generally using paper in place of glass in windows, though making of glass is an ancient industry. In other Oriental countries—Japan, Siam, Malaya—where the forests have not been exhausted, wooden houses are the rule and the people depend even more completely than in China on the plant kingdom. In each, under the impulse of modern contact with the West, a beginning has been made in the utilization of mineral resources, but it is a beginning only, with the possible exception of Japan where the per capita consumption of certain of the metals is now fairly comparable with that of certain European countries.

That a people should depend upon reproducible materials for their well-being, rather than upon exhaustible resources, is not a matter for reproach. It may in fact evidence a lofty and sound philosophy of life, but they work nonetheless under distinct limitations. In our own country, when we depended upon the trees for wood and on animals for work and for leather, when we were content with the small amount of iron the village blacksmith could handle and shape, we traveled for pleasure in buggies and we transported our freight overland in carts or wagons. Now that we have and use metals abundantly and that mineral fuels do our work for us, automobiles carry us in hours over distances we formerly traversed only in days, and trucks transport speedily great loads of goods such as formerly it was, as a practical matter, impossible to exchange between communities. Our railroads, our steamships, our systems

of communication, these and many similar agencies have made our life vastly different from that of our ancestors of a century ago and set it off as markedly from that of our contemporaries in many other lands.

The outstanding characteristic of the last century has been the world-wide rise in the standard of living and the extent to which in America and Europe it has proved possible at least to approximate that standard for the many rather than to exemplify it by the few. In all ages there have been the few who had wealth; the marvel of the present age is the large number who have what, judged by the standards of any previous age, constitutes riches beyond dream limits. The ordinary man in America and much of Europe enjoys from day to day the benefits of possession by society, and in considerable proportion by himself individually, of goods and conveniences that were beyond the reach of the most powerful rulers of ancient times. Quick transportation, instantaneous communication, unlimited artificial light, wide choice of foods, variety of dress, protection from unusual heat or cold, from contagious diseases, from physical danger, relief from much sickness, all these and many more are common everyday possessions, and in the past none of them was common and most were unknown. This profound change in the characteristics and conditions of life is relatively new. In the days of the American revolution small bodies of soldiers walked long distances to fight with a limited number of short-range arms. Their supplies were transported in clumsy horse-drawn vehicles. Communication was by messenger, and both the army and the people depended upon local supplies and household industry for manufactures. Work animals, the wind, and a limited use of water power were all man had with which to supplement his own efforts. When our ancestors came to this continent, the great wealth of fuels and of metals that has since flowed from the mines, lay dormant. A hundred years ago it was present in even greater abundance than now, but it had not been put to use; and in the wide use of minerals lies the greatest difference between our own civilization and those which passed before as well as those now obtaining in Eastern lands.

Little evidence exists to indicate that in general man eats more than his ancestors did. He merely eats more certainly, more regularly, and in greater variety. This regularity of supply and the freedom of choice of material is made possible by modern transportation through which the products of the world are brought to every man's breakfast table, and transport rests on steel rails, steel cars, steel locomotives and steel ships. Had we now only sailing vessels and horse-drawn wagons, an Iowa farmer would never have bananas on his home table. Before the present century, people ate almost exclusively food raised in their particular neighborhood; but the very absence of a wide net of transport lines made it, save in famine years, locally abundant and people ate heartily and cheaply. In undeveloped countries to-day, food is normally cheap and abundant but generally lacking in variety and often deficient in quality.

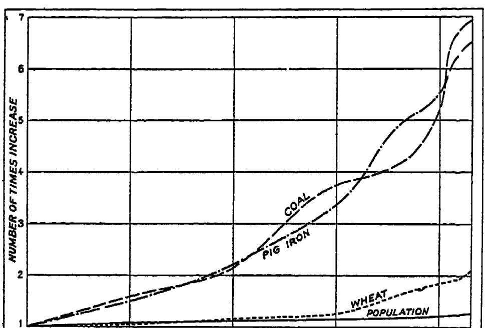

FIG. 1. *Increase in world population, and consumption of wheat, pig iron, and coal since 1870. The curves show marked increase per capita in mineral consumption, and, since 1900, a measurable disposition to turn to wheat for food.*

As to clothing, too, while there has been some increase in the amount of goods consumed per capita, the main change has been in the variety and quality of the goods. The change has been less in the absolute amount of cloth than in the greater freedom of choice the wearer might exercise in selecting his clothing. Skins of animals were doubtless first used, then came textiles woven from wool, cotton and silk. Now rayon or artificial silk is making an increasing place for itself. While style has supplemented utility in creating demand, the increase in total consumption per capita has probably been much less relatively than in the case of metals and minerals.

When, however, attention passes to other things—tools, houses, conveniences, and as already suggested, the means

of transportation and communication—an entirely different condition is to be observed. Modern man has a tool for every use, even tools that automatically make other tools. His houses are larger, better built, more convenient, and more luxurious than any but the very few of those of earlier days, and into even workingmen's cottages have come gas stoves, bath tubs, electric lights, washing and ironing machines, telephones, phonographs, and now the radio—all conveniences entirely unknown but a short time ago. All of these have been made possible by the free use of metals.

In 1820, this country produced and used only 5 pounds of pig iron per capita, but a quick and enormous change was wrought in the hundred years that followed, and in 1920 the amount was 119 times as much, or 597 pounds. It has since increased even beyond this and touched a peak of 809 pounds in 1923. In that year our output was more than twice that of 1903 and nine times that of 1883. This increase in production and use is not singular to iron. In the past 15 years, for example, the world's copper output was as much as in all the whole of the 110 years before, and the demand made on our reserves of other minerals has corresponded. In the summary report of the Committee on Foreign and Domestic Mining Policy, published under the authority of the American Institute of Mining and Metallurgical Engineers and the Mining and Metallurgical Society of America, it is stated that "here in the United States the per capita consumption of minerals has multiplied 10 times in 40 years."[1] C. K. Leith,[2] who has devoted much study to this subject has put the matter in striking terms:

> "The world has used more of its mineral resources in the last twenty years than in all preceding time, and there is nothing to indicate a slackening of the acceleration which has occurred during this period. The production of oil, for example, is now as great in any one year as for the ten years preceding 1900. . . . The last twenty-five years has seen as much gold production as the four hundred years following the discovery of America."

1 "International Control of Minerals," New York, 1925, p. 9.
2 C. K. Leith, "Political Control of Minerals," Foreign Affairs, New York. Vol. 3, p. 541. July, 1925.

That this is not true merely of the United States or of a few metals has been shown by studies summarized by F. G. Tryon and Lida Mann [1] as follows:

> "In the hundred years from the close of the Napoleonic wars to the outbreak of the World War, the white population of the world increased three-fold, but the output of tin increased 26-fold, of copper 63-fold, of the mineral fuels 75-fold, and of pig iron over 100-fold. Lead and zinc showed a corresponding increase. In 1815, aluminum and the ferro-alloys (nickel, vanadium, tungsten, manganese, and chromium) were known, if at all, as curiosities. The mineral fertilizers also are a development of the nineteenth century."

The matter of most significance is that not only the amount and variety of minerals consumed has increased enormously, but there has also been a rapid increase in per capita consumption. Clearly the world is coming to depend upon minerals rather than on the products of the plant and animal kingdoms for its power and its various conveniences and necessities other than food and clothing. Even here mineral fertilizers have been powerful stimulants to the increased production that has been necessary to meet demand.[2] The world's production of fertilizer minerals in 1924 amounted to about 18,000,000 metric tons.

The increasing dependence on minerals and the larger individual consumption of them is most striking in the United States. According to figures courteously supplied by F. J. Katz of the United States Bureau of Mines, the per capita consumption of virgin copper, lead and zinc in this country in 1910 and in 1925 were as shown in the tabulation following. From these primary figures have been deduced those showing the percentage of increase in consumption per person. From still other figures furnished by Mr. Katz, the percentages have been calculated showing how much of our total consumption is now drawn from new metal and what part of the world's supply of these particular metals we now use.

1 "Mineral Resources for Future Populations," Pollak Publications. Vol. 5, p. 114.
2 M. L. Requa has discussed these matters effectively in "The Relation of Government to Industry," Macmillan & Co., New York, 1925. See especially the chapter on "The Significance of Raw Materials," pp. 95-137.

Main

CONSUMPTION OF COPPER, LEAD AND ZINC, 1910 AND 1925, IN THE UNITED STATES

	Copper	*Lead*	*Zinc*
Per capita consumption, pounds:			
Virgin metal, 1910	7.96	8.25	5.35
Same, 1925	12.42	11.67	8.87
Percentage of increase	56	41	66
Percentage of consumption of virgin metal in 1925 to total per capita consumption of same metal	63	74	90
Percentage of total world output of new metal consumed in United States in 1925	54.9	46	39.6

These figures demonstrate clearly the rapid growth in our dependence on the metals, and also the fact that despite the enormous amount of old metal reclaimed and reused each year (492,900 short tons of copper, 226,880 of lead, 74,750 of zinc in 1925) we and the rest of the world are making heavy and increasing demand upon whatever constitutes the world's reserve. It is not only in America that the world is learning to lean heavily upon metals. The wish to possess and the determination to have machines and implements made of metals permeate the whole world. There is a growing use of sewing machines, which are to be seen even in the native huts of Central Africa, and automobiles are now found in every land. These in turn need that the roads be made smooth for the host of machines to follow. Elsewhere than in America and Western Europe, this tendency to require in quantity the product of the mines is as yet but beginning. But the desire is present, and as knowledge of what has proved possible in the more highly industrialized portion of the world spreads the resulting demand will tax the resources of the earth. Spread of knowledge of how other people live is rapid and easy nowadays. Travelers, books, magazines, newspapers, cable messages, radiograms, the radio, and not the least, films, are carrying into every corner of the world and to all its peoples, sharp pictures of what has been found to be feasible as regards supplying goods to the masses by mass production. No people are going to continue indefinitely to be satisfied with what they have so long as they believe it possible to rival others who have more. In varying degrees and at different speeds, the backward peoples of the earth

have set their minds to winning for themselves the material equipment of the more highly industrialized nations. Easy communication, quick transportation and mass production are changing the whole map of industry around the world. The use of vegetable oil and animal fat for lighting purposes continued for centuries after the discovery of their utility. The reign of kerosene as an illuminant was short and the use of electricity is increasing at a rate unheard of before. It is not only that knowledge penetrates to remote villages and awakens desire, but the great volume of goods now manufactured and the increasingly improving system of sale and distribution make it possible to supply the want almost as soon as it is felt.

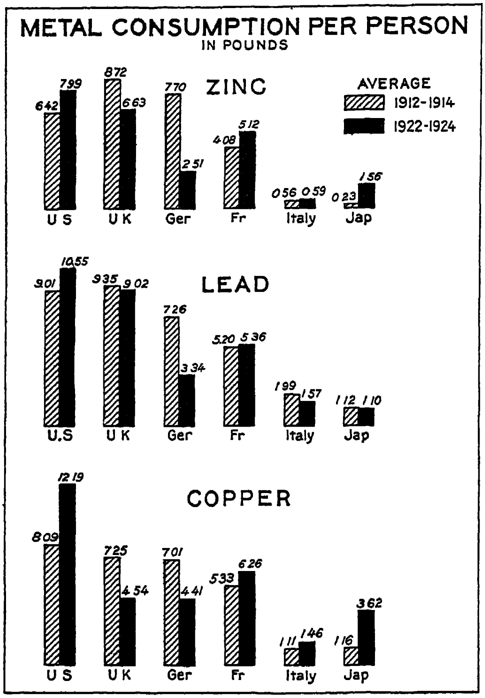

FIG. 2. *Graph illustrating variation in per capita consumption of the leading non-ferrous metals in various countries. To allow all people the same amount per capita as the citizens of the United States would require enormous increases in total production.*

It must be clear that for any country to create and maintain a high state of industry of the type exemplified by the United States, it needs either to possess or to be able to buy immense quantities of the metals. If mankind as a whole is going to enjoy railways, automobiles, steamships, sanitary plumbing, telephones, radios and other necessities of modern peace time activity, to say nothing of the arms and equipment of modern warfare, serious gaps in per capita consumption of metals as between the highly developed and

the less developed countries must be closed, as is indicated by the following table:

PER CAPITA CONSUMPTION OF ZINC, LEAD, AND COPPER[1]
(*In pounds*)

	U. S.	*U. K.*	*Germany*	*France*	*Italy*	*Japan*
			Zinc			
Average 1912-14	6.42	8.72	7.70	4.08	0.56	0.23
" 1922-24	7.99	6.63	2.51	5.12	0.59	1.56
			Lead			
Average 1912-14	9.01	9.35	7.26	5.20	1.99	1.12
" 1922-24	10.55	9.02	3.34	5.36	1.57	1.10
			Copper			
Average 1912-14	8.09	7.25	7.01	5.33	1.11	1.16
" 1922-24	12.19	4.54	4.41	6.26	1.46	3.62

The amount of the various metals and minerals necessary to modern industry varies greatly. Coal and iron are measured in tons, platinum in ounces; and the difference in customary standards of measurement is indicative of the relative amounts used. It must be clear that to import by tons is more difficult than to supply a country with materials of which a few ounces will suffice. It is, therefore, more important both for peace and war to have within the limits of any country ambitious of industrial growth the "tonnage" minerals than the ounce or even the pound-measured minerals. To import steadily materials required in thousands of tons not only makes heavy drafts on shipping and foreign credits, but may well be a critical weakness in time of war. To supply a nation with goods used in smaller quantity, even though of greater unit value, is not so serious a matter. The United States uses platinum but does not produce it to any material extent, and that metal is essential to many important peace-time and war-time uses. But in 1917, enough platinum was smuggled out of Russia and into the United States in the hands of one engineer to save the situation. Had this country not had its immense iron ore mines, coke ovens and steel furnaces, however, it could

[1] Figures for the United States, France, Germany, and the United Kingdom taken from page 106 of the Year Book of the American Bureau of Metal Statistics, 1925. For Italy and Japan the computation was made with 1912-14 data secured from Metallgesellschaft, 1922-24 data from the American Bureau of Metal Statistics, 1925; population data from The Statesman's Year Book.

not have fought successfully regardless of its wealth in other goods. Had our ports been blockaded, and had we lacked the wealth of minerals within our borders, we should have been forced to surrender. Germany's first move in 1914 was to possess herself of iron mines of northern France and she fought the war with materials made from the ore of those mines. Iron, then, is clearly one mineral that must be present in abundance within the limits of any country that aspires to first rank in war or industry, unless the situation be clearly recognized and a continued stream of imports be assured by an equally steady policy of peace or sea control.

Iron ore without coke is virtually useless. A limited amount of iron is still made by using charcoal and iron has been smelted by using anthracite but, having in mind speed, capacity of furnace and standard technology, no large iron industry can be expected to be developed except that based upon the use of coke. Attempts have been made and experimental work is now under way in various countries to produce iron by direct reduction in the electric furnace, or by first making sponge iron (for which purpose inferior coal may be used) and then melting that in the electric furnace. This process is possible technically and, in whole or in part, will doubtless in time find application in special instances; but in speed, capacity and cost it does not compare with manufacture by the usual method of employing blast furnaces and open hearth or bessemer converters. A nation relying upon it could not compete in peace time, and in war would be smothered by the material turned out by a rival having an equal or even a less supply of ore but enjoying possession of coking coal. The latter then is the second of the minerals that must be commanded in quantity by any nation that expects to play an important part in the world's industrial activity.

The definition of coking coal changes from time to time with changes in technology, and it is possible to-day to coke and use in the furnace grades of coal not available a quarter of a century ago. It is to be anticipated that as the years pass ways will be found for coking still other grades of coal, but there is no sound reason to suppose that methods will change sufficiently to make such coals generally avail-

able, and it seems probable that always pure coals, low in sulphur and with moderate amounts of volatile matter, will furnish the bulk of the coke. Such coals form a relatively small part of the world's total reserve.

Ordinary coal, for use as fuel, is no less essential, though for power uses, hydro-electric power may be substituted so far as it may be available. Petroleum also has come into this field and, not only as a lubricant and an illuminant, but now more than all else as a source of power in internal combustion engines, is essential to modern life and industry. Substitutes produced as by-products in making coke from coal can take the place of petroleum but, as is always true in using substitutes, the introduction of another step in the process of production increases the cost and handicaps the user. Natural petroleum is therefore important if not absolutely essential.

The extent to which the work of the world is done by power and the difference in the amount used by various peoples is not generally appreciated. T. T. Read has recently made some interesting calculations of the world's output of work [1] from which it appears that the total measurable amount of work done in fifteen countries with energy derived from coal, petroleum, and waterfalls is more than five times as much as the work done by the people of the same countries with their hands. The ratio of hand labor to mechanical labor varies from country to country. In the United States, where the ratio is 1 to 35, it is as if each of us had 35 mechanical slaves working for us. It is this use of the energies of nature to multiply the work of men that has permitted the rapid piling up of goods and the rise in the standard of living. No people that would lead in industry can any longer depend upon the work of their hands only. The waterfalls and the coal mines must be made to yield the force which does the hard physical labor, man serving rather to direct force than to supply force. From every point of view the possession of coal in quantity, and if possible of coking quality, is essential.

In the chemical industries, which now play such an im-

1 Thomas T. Read, "The World's Output of Work," Mechanical Engineering, p. 531, May, 1926; "The American Secret," Atlantic Monthly, March, 1927.

portant part in our lives, sulphuric acid plays a rôle comparable to that which iron plays in general manufacture. It is the most essential and widely used of the chemicals, the major peace-time demands being for (1) manufacture of fertilizer; (2) refining petroleum; (3) pickling iron and steel; (4) manufacture of nitrocellulose, nitroglycerine, celluloid and similar products; (5) general chemical and metallurgical products. Approximately one ton of acid (50° B. basis) is required to treat one ton of phosphate rock in making superphosphate. For refining petroleum approximately 0.40 pound is necessary per gallon of oil. For pickling steel sheets preparatory to galvanizing or trimming them, many thousands of tons are used every month. In making explosives A. E. Wells and D. E. Fogg [1] estimate the consumption as follows:

	Pounds of Acid (based on 100 percent H_2SO per pound of product)
For manufacture of smokeless powder from cotton linter	2 3
For manufacture of T. N. T. from toluol	2.2
For manufacture of picric acid from benzol	6.2

The large demand in industry may be illustrated by the fact that in 1914 the United States produced 3,800,000 tons (50° B.) having a value of nearly $25,000,000. When the armistice was signed on November 11, 1918, the plant capacity was 9,600,000 tons and building on a large scale was under way.

Sulphuric acid is a low-priced commodity which does not appear as such in the finished product, so its importance to industry is rarely appreciated. It is none the less absolutely necessary in quantity to any large industrial center of diversified manufactures. Its most essential constituent is sulphur, which in turn is found in nature not only as an element but in combination with iron, zinc, lead, and other metals. In practice, sulphuric acid is made by burning brimstone or roasting the sulphides and combining the fumes with moisture in plants suitably designed. Sulphuric acid is heavy, and is difficult and dangerous to transport. Before

[1] A. E. Wells and D. E. Fogg, "The Manufacture of Sulphuric Acid in the United States." Bull. 184, U. S. Bureau of Mines, 1920. P. 20.

the war it was rarely shipped in the United States more than 200 miles. If used in large quantities it is more economical and safer to bring the sulphur to the place of manufacture than to attempt to move the acid itself. An assured supply of sulphur in some form within a country is therefore essential to economic and strategic independence.

Aside from the minerals already discussed—iron, coal, petroleum and sulphur—which in the main are the "tonnage" minerals, there are many others essential to modern industry. Just as a small amount of yeast must be used to make bread, so a few pounds of manganese are essential to making a ton of steel. The amounts demanded of these minerals are, however, smaller and in finished products they ordinarily enter in such minute amounts per unit that their cost is a less direct matter of concern to the user. Tin, to cite one example, is a metal essential to many American industries. The United States consumes more than half the world's output and produces virtually none; but, save in great emergencies, no great practical inconvenience results from America's dependence on the Far East and Bolivia for its supply, and doubling the price has not operated to restrict imports. Other essential minerals sporadically distributed around the world are used in such small quantities that dependence upon imports is feasible. The ferro-alloy group, tungsten, manganese, vanadium and others, illustrate this situation. They must be had, but possession of them alone will not permit the foundation of a large industry and by trading, stocking or temporary substitution, a national shortage can usually be met.

The non-ferrous metals—copper, lead, zinc, aluminum, tin, antimony, mercury and others—form another group. All are essential in varying degrees and amounts. If not present within a country they must be imported. It happens that in the production of the first three, sulphur ordinarily is or may be derived as a by-product so that they form an essential portion of a nation's economic and strategic defense. While per pound they cost more than iron, coal, and petroleum, they are needed in smaller quantity and it is feasible to rely upon imports and still build up a considerable industry. England, France and Germany,

for example, are large importers of copper and to a less degree of the other metals mentioned.

The rare and precious metals, including especially gold and silver, constitute still another class of minerals characterized by compactness, ease of transport, and high exchange value. Gold mines are a bulwark to a nation; but other goods may be substituted for gold in trade and, indeed, in putting labor and supplies into mining gold and then using the latter for international exchange, a process of condensation of goods to save transportation and storage charges is what really takes place. While possession of the mines of Larium was a large factor in the greatness of Athens in what should have been called in return the "silver" rather than the "golden" age, the mines of the Rand did not save the Boers from defeat, and it is improbable that any virile nation possessed of other resources will miss its destiny from being forced to buy with other goods rather than mine its gold.

The non-metallic minerals, other than the fuels, constitute still another group. They are characterized by bulk and correspondingly low unit value. They are also widespread. Sand, gravel, clay, stone, gypsum, cement materials —these and others of this group are found in most countries and their extensive use is possible to most people. While employing cement liberally as we now do predicates a previous use of fuel to convert limestone and clay into cement, the Egyptians and other ancients found it possible to erect enormous stone structures despite the absence of fuel and the limited amount of metal they had for making tools. Adobe or stone houses are found in many countries where poverty is widespread and where minerals in general find only limited application. It is not probable that any considerable nation will be seriously handicapped by lack of sufficient supplies of non-metallic minerals though many of them are essential in modern industry.

Any nation that aspires to industrial leadership or strategic independence must have or acquire stocks of many minerals. If sufficiently rich in other materials it may depend upon trade for securing most of them, but unless it has within its borders a supply of the "tonnage" minerals, coal,

iron and sulphur or sulphides, it is under bonds to keep the peace.

While the countries of the Orient are capable of yielding minerals and mineral products in wide variety, there is no warrant in our present knowledge or in the probabilities we may properly infer from it, for considering them extraordinarily rich in minerals.[1] There are rich deposits and there are extensive areas of mineralization. The East, too, holds, at least for the present, a dominant position in production of certain metals, such as tin and antimony; but speaking in terms of comparison, the East is not known to be possessed of mineral wealth comparable to that of western North and South America. Probably Australia and Africa are also destined to be relatively more important factors in supplying the world's trade in mineral products than is the Far East. It is to be remembered that on any reasonable hypothesis as to growth of modern manufacturing and commerce the bulk of such mineral wealth as occurs in the Far East will be needed for home consumption, and the world in general is mainly interested in goods that enter international trade directly or indirectly—in short, goods forming part of the exportable surplus of each country. Mineral wealth capable of being so used is to be found in the East, and in amounts large enough to furnish a basis for most satisfactory individual enterprises or even groups of enterprises; but from the point of view of the larger world economy the raw materials with which the East will pay for goods manufactured in the West must in the main be food or related agricultural products.

The present contribution of the Far East to the world's trade in minerals constitutes but a small percentage, save in antimony, tungsten, and tin. In the accompanying figure, the circles are drawn proportional in diameter to the percentage of the world's output of the production in each case from the country indicated. It will be noted that China furnished 80 percent of the antimony and 63 percent of the tungsten in 1924, while Malaya, Siam and the Netherlands East Indies together supplied 60 percent of the tin.

[1] C. K. Leith, "The Mineral Resources of the Far East." Foreign Affairs, N. Y., April, 1926.

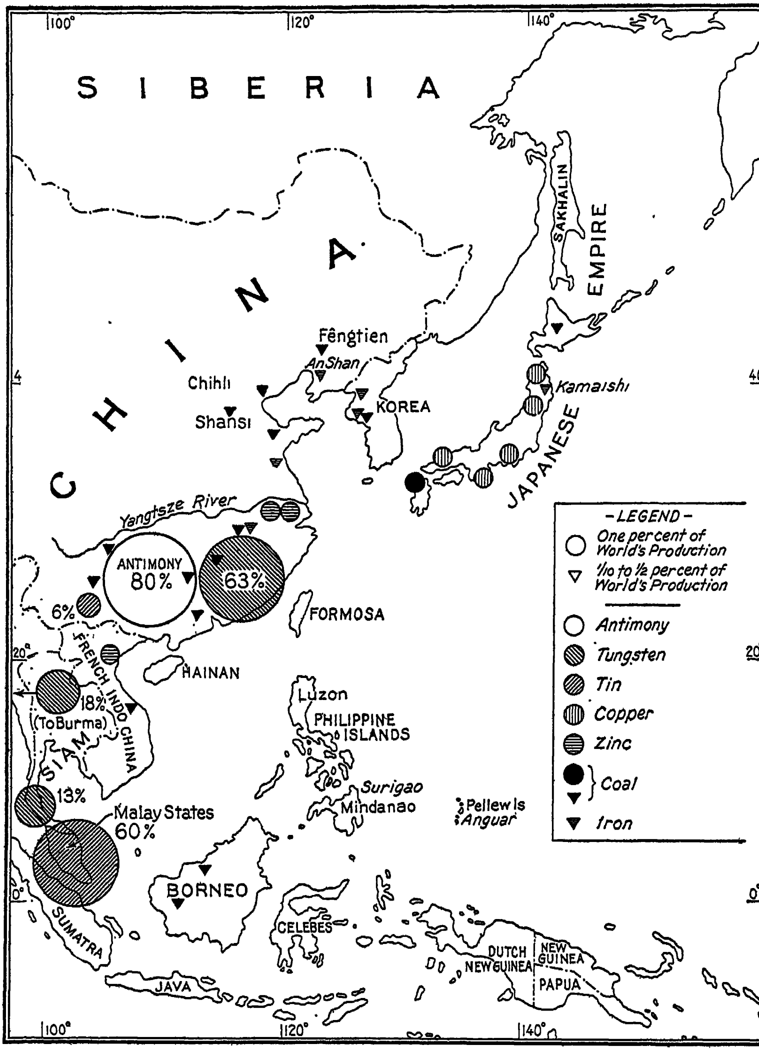

FIG. 3. *Map showing the percentage of the world's production of various minerals derived from Far Eastern countries in 1924.*

To this China added 6 percent; Japan supplied 5 percent of the copper; no Eastern country furnished more than 1 percent of the world's output of any other mineral. Collectively the Eastern countries now furnish 4 percent of the coal and less than 2 percent of the steel made in the world.

So much for mining as now developed in the region; the practical question is what resources there are which remain to be developed.

China has long been believed to be a country of untold mineral wealth. This belief, along with that of the general richness of the country owes much to the descriptions of Marco Polo. In 1274-1295, when that enterprising Venetian traveled through the Far East, China did surpass Europe in material wealth and general prosperity, and in Marco Polo's account of the wonders of what he saw in Cathay there are many references to rich gold and silver vessels as well as to other objects made of metal. For centuries before Polo's time the Chinese had been using the common metals, and while to this day they have not come to employ them as freely in their industries as is customary in Europe and America, they even then used them widely. Wherever the traveler went he found metals in use as widely if not more so than was then customary in Europe. It was a natural assumption that the quantity of metal and of the minerals from which it could be derived was large in that part of the world. Later travelers confirmed rather than questioned this conclusion. In particular, Baron Ferdinand von Richthofen established firmly in general confidence the belief that China's resources of iron and coal were unlimited. Von Richthofen's description of the coal and iron fields of Shansi has often been quoted and it probably has had more influence than any other single piece of writing in establishing the widespread belief that China possesses the "untold mineral wealth" in which after-dinner speakers have such firm faith. Unfortunately, more recent investigations have failed to substantiate conclusions drawn from the earlier work.

H. C. Hoover, who with a considerable staff, studied North China before 1900 under the auspices of Li Hung-chang and the Imperial Government, found that as regards gold, copper, and related metals the area was generally poor rather than rich.[1] With the exception of a few localities he found little to encourage hope of developing a large

1 H. C. Hoover, "Metal Mining in the Provinces of Chihli and Shantung, China." Institution of Mining and Metallurgy (London), Vol. 8, 1899-1900.

modern metal industry. In the Yangtze valley a less elaborate investigation conducted by Pope Yeatman in 1903 led to disappointment.[1] In the Southwest, the first glowing accounts of mining wealth made by French engineers in advance of the building of the Yunnan railway were revised when subjected to more exact observations and careful analysis. When the Pekin Syndicate was formed there were large expectations of profits from the introduction of modern methods in the Shansi iron fields. W. H. Shockley's [2] studies showed, however, that the iron orebodies were individually limited as to extent and the whole mode of occurrence was such that there could be no hope of feeding large modern blast furnaces from them. The Pekin Syndicate therefore wisely parted with its Shansi rights and has confined attention to developing coal in Honan. The cumulative effect of those various investigations, and only a few out of many have been cited, has been to induce among foreign and the better informed Chinese engineers a healthy skepticism as to the extent and value of China's mineral wealth.[3]

While this view has not yet influenced the general public, nevertheless—coupled with the disturbed political conditions, and in part the unsatisfactory condition of Chinese laws regarding mining—it has acted as a strong influence against any active development except of coal mines. The only large mining enterprises in China in which foreigners have taken part are half a dozen coal companies. The Japanese have a couple of iron and steel works in Manchuria, at Anshan and Penhsihu, and control blast furnaces at Tayeh. The Chinese have built up an important antimony company and one iron and steel producing plant of size. Two other blast furnaces have been built but are not operating at present. There are gold and tin-mining districts that in the aggregate yield considerable metal but Chinese mines are small mines, as measured by those of other countries, and of the approximately $50,000,000 an-

1 Mining and Scientific Press, pp. 270-273. San Francisco, 1913.

2 W. H. Shockley, "Notes on the Coal and Iron Fields of Southeastern Shansi, China." Trans. A. I. M. E., Vol. XXXIV, pp. 841-871, 1904.

3 See the various reports of the Geological Survey of China and a general summary by C. Y. Wang on "The Mineral Resources of China," read before the China Institute of Mining and Metallurgy, and printed by the Tientsin Press.

nual output, it is estimated by the Geological Survey of China that the larger part comes from small native mines.

The universal error made by the early observers was to mistake widespread occurrences of minerals for abundance. In point of fact the greater number of orebodies known are of small dimensions and only adapted to the simple, low capital cost method of mining followed by the Chinese. Native workmen, mining at seasons when they are not needed on the farms, are satisfied with a smaller wage than would be possible if the work were continuous and formed their only source of support. So with their crude appliances and diminutive furnaces the Chinese have been able to operate mines that would not now be considered in Western countries. The bulk of the mining so far done, being on small orebodies, is properly enough accomplished by methods that have long been out of date where large-scale mining is the rule. From the point of view of probable mineral production the part of China which is open to exploration and development now, or which seems likely to be so open within the next few years, is comparable rather to that part of the United States east of Chicago and St. Louis than that west of Denver. One familiar with the history of mining in America and cognizant of the multitude of mineral prospects in the southern Appalachians and the difference in development from that in Montana and Arizona will realize what this means. There is another China, a region of great deserts, high mountains, and abundant eruptive rocks, but it is far in the west. It is a region of high altitudes and sparse population offering enormous obstacles to railway building and no inducement likely to cause completion of lines through it for many years to come. So far as competent exploration has gone, there is yet no definite information of large orebodies, but in a number of districts the geology is similar to that in the Cordilleran region of America and it is entirely possible that major mines of gold, silver and the non-ferrous metals in general will ultimately be developed in this region.

A widespread but mistaken impression prevails that the resources of the Far East are largely unknown and almost wholly unmeasured. In fact, mining was a flourishing in-

dustry in the Orient before our own ancestors had learned to burn coal, and in the case of minerals for which the peoples had use, the outcrops of the orebodies have long since been mined away. One of the major difficulties in applying modern methods to Eastern mines is the extent and uncertain position of ancient workings. In every important mining district from Japan to Java ancient workings are the guide to the finding of ore. The ancients, it is true, had no use for tungsten and a few other minerals which we ourselves have but recently begun to use, and as a result surface deposits of such minerals have only recently come to be mined. Neither did they have use for petroleum or knowledge of how to obtain it in quantity. It will be remembered that our own development of a petroleum industry began only in 1859. It is not surprising, therefore, that such petroleum fields as exist in the Far East are mainly still to be found and developed. But for the coal, iron, and common non-ferrous minerals the reverse is true. No reason exists to anticipate the finding of great deposits not already indicated by the ancient workings. Until recently an exception would have held true as regards iron ore since the ancients depended upon deposits of no value under modern conditions and failed to recognize the types of ore that feed modern blast furnaces. The past twenty years has, however, seen an intensive search for iron ore from Siberia to India; and since an iron orebody suitable for modern industry must contain millions of tons, it is sufficiently large to preclude many being overlooked when intelligently searched for by competent engineers. It is further to be remembered that iron ore has value only when situated where it can be used. A large body of high grade ore in Tibet, in the absence of coking coal in particular, might almost as well be in the moon so far as any probability of its use by man is concerned. Tonnage minerals, to enter into industry require transportation, manufacturing facilities, water, markets and many other subsidiary things. Part of these may be present, it may be physically possible to supply any or all of the others; but none the less a steel plant in the heart of the Gobi desert, to cite an extreme case, would have a hard time serving mankind. It is also

true that changes in technology may be expected in the future, as in the past, and no one can say surely what may be true a few centuries from now. But it is also true that no considerable bodies of ore are known in the Far East that are not reasonably amenable to present processes and that, for present purposes, studies that throw certain light upon the course of events to be expected in the next few centuries or even the next few generations, are sufficiently useful.

It has been said that a large body of fact now exists as regards the ore deposits of the Far East. It is in the main embodied in technical publications or in private reports made to mining companies or exploring syndicates. The knowledge that is in the hands of the general public is largely that found in general books on the various countries, almost none of which were written by geologists or engineers. The writers had only secondary information, most of it being inaccurate and seen through a golden haze of tradition. The more scientific and exact data collected in recent years have not yet found their way into general literature.

Any estimate of the mineral resources of a region must be based upon a knowledge of its geology, and for the Far East there are two great outstanding sources of data, both —as it happens—based upon studies in China. These are the works of Ferdinand von Richthofen [1] and in the report of the Carnegie Institution.[2] Von Richthofen was misled, as later detailed, into imputing larger economic importance to certain of the deposits than present knowledge permits, but his report is the great early classic on the geology of the largest country in the Far East. Willis' report is a comprehensive firsthand study by highly competent observers of the more critical areas. From these, with his world wide knowledge, he has generalized helpfully as regards regions less carefully studied by his staff or known only through reports by others. It was not his purpose to study ore deposits as the object of his investigations was

1 China: Ergebnisse eigener Reisen und darauf gegründeten Studien. Berlin, 1877; Letters 1870-1872 to the Shanghai Chamber of Commerce. See Ed. Shanghai, 1903.

2 Research in China, Willis, B.; Blackwelder, E.; and Sargent, R. H. Volumes 1-3. Carnegie Institution, Washington, 1907-1913.

scientific research only, but Willis is a mining engineer as well as a geologist, and after his return summarized existing knowledge of the mineral resources of China most helpfully.[1] Many other works of importance exist, a number of which will be cited in this text as they are referred to, but no attempt has been made to compile a complete bibliography. A list selected by J. W. Frey appears later.

For most of the countries, Siberia, Japan, China, Indo-China, Philippine Islands, Netherlands East Indies, Federated Malay States, modern geological survey staffs have now been at work for some years and have issued numerous reports of high value that are generally accessible in technical libraries. A number of them will be specifically mentioned later. The researches of the Geological Survey of India have thrown much light on Yunnan.[2] This same province has been studied and restudied by members of the Geological Survey of Indo-China. Many foreign geologists and engineers have studied individual districts or mines and in most instances have been able to publish the results of their observations, or their reports have been accessible to the author of this book. Also, there is a growing group of well trained native engineers who are contributing rapidly to accurate knowledge of the region. Among those who have added to the knowledge of China there may be mentioned J. G. Andersson, P. Brossart, F. G. Clapp, W. F. Collins, N. F. Drake, M. L. Fuller, H. C. Hoover, K. Inouyè, W. Koert, H. Latenois, M. A. Leclère, R. M. Raymond, T. T. Read, W. H. Shockley, F. R. Tegengren, E. C. Thurston, V. K. Ting, C. M. Weld, C. Y. Wong, W. H. Wong, Pope Yeatman, M. B. Yung, and the staff of the New York Orient Mines Co. The latter, an American syndicate, headed by Col. William Boyce Thompson, between 1916 and 1925 carried on a comprehensive study of the mineral resources of the Far East under the direction of John Wellington Finch who has kindly consented to the use here of the material collected at large expense by that

1 Bailey Willis, "Mineral Resources of China," Economic Geology, Volume III, pp. 1-36, 118-133. 1908.

2 J. Coggin Brown, "Contributions to the Geology of the Province of Yunnan, in Western China." Records, Geol. Surv. India, Vol. XLIII, p. 3, pp. 173-228, 1913. "The Mines and Minerals of Yunnan, South China." Mem. Geol. Surv. India, Vol. XLVII.

Company. At various times in the course of the work the staff of this Company included in addition to Mr. Finch, himself a widely experienced and most capable mining geologist and engineer, Fred Searles, Jr., George O. Scrafe, T. R. Drummond, Norman L. Wimmler, J. E. Johnson, Jr., Marshall D. Draper, Edwin W. Mills, G. H. Cady, Roger Gannett, and the author of this book, who for three years served as chief of explorations and for a longer period was a consultant. Messrs. Drummond and Wimmler came to the staff from nearly two years' similar study of the Philippines for an associated group, and the petroleum resources were later investigated by geologists in the service of a friendly corporation. An adequate staff of foreign trained Chinese assistant engineers was employed and at one time a large number of drill men and mining engineers was temporarily employed in a detailed study of certain ancient workings in Yunnan. The studies made by this Company were probably the most comprehensive ever conducted by a private company in the Far East and the numerous reports made in the course of the work have been freely drawn upon in the preparation of this volume.

In the preparation of this manuscript the author has had the constant assistance of J. W. Frey, of the University of Wisconsin, who has compiled the tables of statistics, the general bibliography, and has verified the references. Willys R. Peck, long the Chinese Secretary of the American Legation at Peking and now on detail at the State Department in Washington, has kindly checked the spelling of Chinese names. W. B. Heroy, of the staff of the Sinclair Consolidated Oil Corporation, has furnished the chapter on Petroleum, and Wilber Judson, of the Texas Gulf Sulphur Co., has kindly read and criticized the chapter on Sulphur. Thomas T. Read, formerly a member of the faculty of the Pei Yang University at Tientsin and my long time associate in various positions, has performed a like service for the whole manuscript.

CHAPTER II

COAL FIELDS OF THE FAR EAST

COAL, as already indicated, constitutes the most important mineral for any industrially-minded people. It has been called the mainspring of civilization and in very truth it is the most powerful agent man has seized upon to do his work. Two pounds of coal properly utilized will do the work of one man one day and a long ton is equivalent to about 1100 man-days of work. By calling to their aid the stored energy of this mineral peoples multiply their effective population without making corresponding drafts on their food supply. Petroleum, water-power, the wind, and work-animals all aid man in a similar manner, but to a less degree. The first will be separately considered, but in the table below is placed the population of a number of countries and their equivalent effective population or work output, as measured by man power times per capita mechanical power used.

POPULATION AND WORK OUTPUT

Population figures for the year 1921; work output on the basis of population plus equivalent man power produced from water-power and fuel, stated in terms of man-days per year including human and mechanical work; figures in thousands, the "000" being omitted.

	Population	*Work Output*
United States	105,711	3,805,596
United Kingdom	44,169	1,060,056
Germany	59,853	897,795
China	427,679	513,214
India	247,003	345,804
France	39,210	341,127
Russia	142,038	213,057
Canada	8,788	193,336
Czechoslovakia	13,611	156,526
Belgium	7,466	141,854
Japan	55,963	123,118
Italy	38,901	120,593
Poland	27,558	115,743
Australia	5,436	54,360
Holland	6,865	51,487

This table is based upon calculations made by Thomas T. Read [1] and while he has made various assumptions of equivalence concerning which minor differences of opinion are permissible, the figures may be accepted as representing the essential facts in the right order and proportion. It makes clear what an enormous advantage any country has which contains within its border important coal fields and how seriously any other country is handicapped if it must import its coal.

The per capita consumption of coal varies greatly in different countries being mainly a function of their relative industrialization. The people of the United States and of Great Britain use about the same amount, on the average, for domestic heating but for power production and metallurgical industries there is a marked difference. In the table below, the figures for various countries in recent years are given. They illustrate the growing use of coal and the differences in average consumption as between different countries.

PER CAPITA CONSUMPTION OF COAL [2]

(*In tons of 2240 pounds*)

	United Kingdom	*United States*	*Belgium*	*Germany*	*France*	*Italy*	*Japan*	*Russia*
1886-90	3.66	2.04	2.28	1.18	0.82	0.12	0.03	0.06
1891-95	3.68	2.38	2.39	1.30	0.93	0.13	0.05	0.08
1896-00	3.93	2.72	2.69	1.56	1.08	0.14	0.09	0.12
1901-05	3.93	3.67	2.82	1.69	1.15	0.17	0.12	0.15
1906-10	4.04	4.43	3.10	2.00	1.34	0.25	0.19	0.18
1908	3.99	4.05	3.05	2.03	1.35	0.24	0.19	0.19
1909	3.99	4.41	3.01	2.00	1.38	0.26	0.20	0.19
1910	4.01	4.72	3.21	1.97	1.39	0.26	0.21	0.17
1911	4.08	4.54	3.21	2.00	1.44	0.27	0.24	0.19
1912	3.83	4.82	3.35	2.12	1.48	0.28	0.26	0.22
1913	4.14	5.04	3.42	2.25	1.56	0.29	0.28	0.26
1920	3.99	5.15	2.99	1.72	1.42	0.14	0.44	0.06
1921	2.73	3.97	2.66	1.80	1.28	0.18	0.39	0.07
1922	3.42	3.81	3.21	1.91	1.51	0.22	0.42	0.08
1923	3.62	5.09	3.72	1.27	1.68	0.22	[3]	0.09
1924	3.85	4.40	4.17	1.69	1.89	0.27	[3]	0.10

1 "The World's Output of Work," Mechanical Engineering, p. 531, May, 1926.
2 Source: Coal Tables, 1912. Parliamentary Paper No. 285, H. M. S. O. Lond. 1914; Coal Tables, 1924, Parliamentary Paper No. 168, H. M. S. O. Lond. 1925. The coal consumption in the United States has been reduced recently as a result of the larger use of fuel oil and more efficient methods of burning.
3 Not available.

Statistics are not available for presenting the per capita consumption of the Far Eastern countries other than Japan. In China, the coal output in recent years has ranged from 18,000,000 to 25,000,000 tons. On the basis of the latter figure and accepting the estimate of 400 million for the population, the consumption would be at the rate of 14 pounds per capita per year. The corresponding figures for consumption in the United States in 1926 would be 12,000 pounds.

The present state of the coal mining industry in the various Far Eastern countries is reflected in the following table showing the production in recent years.

COAL PRODUCTION IN THE FAR EAST[1]

(In thousands of metric tons)

	Japan	*China*	*Netherlands East Indies*	*Indo-China*	*Federated Malay States*
1921	27,675	19,872	1,212	920	304
1922	29,481	19,954	1,032	988	286
1923	30,941	22,681	1,156	105	323
1924	32,213	20,524	1,470	...	...

With differing rates of consumption and with wide differences in the number of people to be provided for, the matter of reserves becomes one of first importance. In the table following the estimated reserves of various countries in the world are given, these figures being based upon the compilation made for the International Geological Congress which in 1913 made a general survey of the world's coal resources.[2] Such estimates are subject to correction and revision as information accumulates. They are less exact in the countries less thoroughly surveyed and that situation obtains as to the Far East. They do, however, represent the best information available at the time and warrant serious consideration. The special corrections that should be applied to the countries herein discussed will be noted separately and later. While later studies have changed the absolute figures, the general order is correct.

1 Source: Japan; "Mining in Japan," p. 32, Association of Mine Owners, 1926. China: 1921-1923, W. H. Wong in China Year Book. Other figures from "Mineral Industry," 1925.

2 "Coal Resources of the World," Vol. 1, p. 165, Toronto, 1913.

ESTIMATED PROBABLE COAL RESERVES [1]

United States [2]	3,838,657
China, including Manchuria	996,795
Canada	819,465
Germany	163,516
Australia	163,253
Poland	155,652
India	78,555
Russia	60,037
United Kingdom	48,034
Czechoslovakia	25,953
France	13,079
Belgium	11,000
Japan, including Korea	8,051
Holland	4,193
Italy	191

The small table below includes a statement of proved and probable reserves for the Far Eastern countries where such estimates were made by the International Geological Congress. In Siberia, there are extensive coal fields, though mainly in the interior, and in the Philippine Islands, Siam, the Malay States, and Netherlands East Indies, there are fields in the main of low-grade coal but no numerical estimates are available. The figures here presented do not discriminate as to the grades of the coal, but of the "actual" reserve of China 8,883 million tons is considered to be anthracite or semi-anthracite and 378,581 to be bituminous. Very little of that here included is below this in grade. Japan has little anthracite and about 10 percent of the "actual" reserve is of sub-bituminous or lignitic grade. The probable reserve of Indo-China is all classed as anthracite or semi-anthracite.

COAL RESERVES OF THE FAR EAST

(In millions of metric tons)

	Proved	*Probable*	*Total*
China	18,666	976,921	995,587
Manchuria	409	799	1,208
Japan, including Korea	981	7,070	8,051
Indo-China	...	20,002	20,002

From these figures it is apparent that China is believed by geologists to contain one of the great coal reserves of

1 From figures compiled for the International Geological Congress in 1913, in millions of metric tons. The figures have been redistributed, where necessary, to conform to post-war divisions of territory.
2 Alaska included. Alaska (16,293).

the world and much the largest amount known in the Orient. It will be convenient, therefore, to begin with a consideration of the Chinese coal fields.

In order to understand the occurrence of the mineral deposits of any country it is necessary to have in mind its geology. While no attempt will be made here to present this subject save in the broadest possible terms, a general

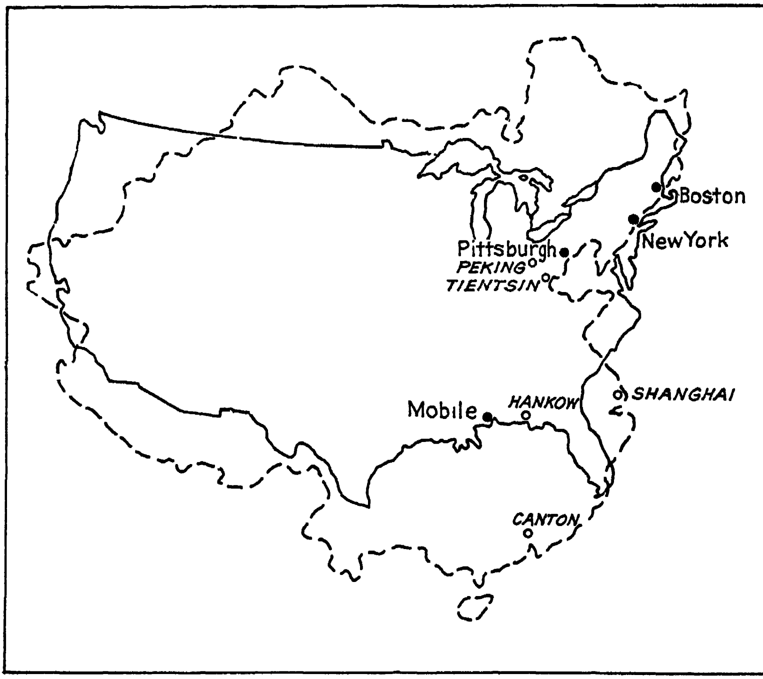

FIG. 4. *Map illustrating the relative size of China and the United States. The correct latitude has been preserved in superimposing the outlines of the two countries.*

outline has been prepared and inserted to avoid repetition in the various succeeding chapters.

It may be helpful first to present a few general facts as to the position of China. If a map of the Republic, including the great dependencies, be superimposed upon one of North America drawn on the same scale, the result is as in the figure below, Mercator's projection having been used in both cases for convenience.

The latitude has been faithfully preserved but the longitudes altered to bring Peking in about the same position as Columbus, Ohio. On this basis Shanghai would fall east of Jacksonville, Florida, and Hankow not far from Mobile. It will be noted that China covers a larger area than the United States, extending further to both north and south. The most significant difference is the fact that China has but the one sea coast and that its Far West differs from ours in having no outlet save by long overland journey. The principal north-south railway in China, the Peking-Hankow, runs in a position corresponding in a way to one which might extend from Columbus to Mobile.

The larger part of Chinese territory is comprised in the dependencies of which Manchuria, Mongolia, Turkestan and Tibet remain partly under Chinese control. Formerly, Korea and much of Indo-China also belonged to the then Empire. At various times in the past these several countries have been won and lost. The eighteen provinces which constitute China proper correspond roughly, in extent and relations to the ocean, to that part of the United States lying east of a north-south line through Omaha. There is, however, a most important difference in that, whereas the greater portion of the area in the United States indicated, consists of fertile prairies and level river lands, the corresponding region in China is prevailingly mountainous. According to Eliot Blackwelder,[1] less than one-tenth of the area is even moderately flat, while Bailey Willis makes the statement that the great plains of the Yangtze, Yellow River, and even southern Manchuria combined only equal some 200,000 square miles as against 1,200,000 square miles of hilly to mountainous land in the remaining area under study. The part of China which is easily accessible and which is usually visited by tourists is a great fertile bottom-land similar to the lower Mississippi Valley, but this is by no means representative of the larger part of China and many erroneous conceptions of the country and the people are widespread because of failure to comprehend or to remember the fact.

1 "The Geologic History of China and Its Influence Upon the Chinese People," Pop. Sci. Mo., Feb., 1913.

Making further rough comparisons we may think of the great plain of eastern China as extending west to some such position as Pittsburgh in the United States and being met there by the mountains separating the plain of China from the prairies of Mongolia and Siberia, which would reach out to the coast at about Boston. In the south, in place of Florida and the northern half of the Gulf of Mexico, would be another mountain area, in which the altitudes would be less but the local relief equally pronounced. This mountainous country would curve around to the west to meet the other belt already indicated as reaching down from the north. Out in the big plain so indicated there are isolated fringing hills on the west and south while in the province of Shantung a group of important mountains rises above the plain in position that would correspond roughly with Eastern Virginia. Szechuan, a great basin in the heart of the mountains, would occupy a position corresponding somewhat to that of Arkansas and Eastern Oklahoma. Mongolia, Turkestan and Tibet lie so far inland and are so inaccessible that no general discussion of them need be entered into here.

The climate of China by no means corresponds part for part with the areas of the United States indicated above. In the northwest it is dry and the winters are severe, as in Montana and Wyoming. In the southeast it is humid and semi-tropical, and approaches the conditions in the Philippines. These are the extremes.

In 1914, D. F. Higgins summarized the existing available geological knowledge regarding China in a small pamphlet for private circulation. Below is the general table of formations that he compiled, with changes to conform to later knowledge of the Tertiary especially.[1]

The greatest unconformities, marking periods when the sea left the area and mountains perhaps were formed, occur (1) above the Archean; (2) above the Eo-Proterozoic; (3) above the Neo-Proterozoic; (4) above the Cambro-

[1] An excellent general sketch of the Geology of China by W. H. Wong appears in "The China Year Book," 1925, pp. 65-78. Tientsin, 1925. A similar sketch, together with summaries of the various estimates of coal reserves and brief comment on them, appears in "A Geographical Study of Coal and Iron in China," by Wilfred Smith. (The University Press of Liverpool Ltd., Hodder and Stoughton, London, 1926, 83 pages and maps.)

THE GEOLOGICAL COLUMN

Cenozoic	Quaternary	Recent	
		Pleistocene	
			Period of making present mountains.
	Tertiary	Pliocene	Scattered clays and lignites.
		Miocene	Not certainly identified.
		Oligocene	Minor beds Manchuria to Shansi.
		Eocene	Found in scattered sunken areas in North China.
	Cretaceous		Not certainly identified in China.
	Jurassic		The Permo-Mesozoic system of China.
	Triassic		
	Permian		
	Carboniferous	Upper.	The Carboniferous of China.
		Lower.	Scarcely represented in China.
Paleozoic	Devonian		The Siluro-Devonian system of China.
	Silurian		
	Ordovician	Upper.	Scarcely represented in China.
	Cambrian	Lower.	The Cambro-Ordovician (Sinian) system of China.
Proterozoic	Neo-Proterozoic		The Nankow series of North China.
	Eo-Proterozoic		The Wu-t'ai series of North China.
Archeozoic (*Archean*)	Laurentian		The Tai-shan complex of China.
	Keewatin		

Ordovician; (5) local unconformities may be found at different horizons in the Permo-Mesozoic and a great one follows the Jurassic. It is uncertain whether or not there is an unconformity between the Devonian and the Carboniferous.

Archean:—According to Willis,[1] this term has been used in China, as it has frequently elsewhere, to cover various metamorphic but usually ancient rocks. Generally, it is applied to any highly metamorphic or igneous rocks which

1 Research in China. Carnegie Institution, Washington, 1907-1913.

are older than the oldest clearly recognized sediments present. It has thus been made to do duty for rocks really of widely different age. Moreover, intrusives which are present have been grouped with the schists although clearly younger and possibly very young. Nevertheless, there is in China as elsewhere a certain fundamental complex which it is possible to discriminate, at least in part. As described by Willis in Shantung, the old complex consists "chiefly of metamorphic schists and gneisses of indeterminate original character; associated with them is a large proportion of metamorphosed igneous rocks and a very small proportion of metamorphosed sediments. The metamorphics are intruded by granites which are relatively young, though in large part, probably pre-Cambrian in age. The structure of the gneisses and schists is exceedingly intricate; it is characterized by universal schistosity; by a common banding; by complex shearing, thinning, thickening, plication, and flow of bands; and such an intricate arrangement of the very variable petrographic facies of the schists and gneisses as makes impossible any easy stratigraphic studies." In a general way the Archean rocks correspond to the lower Huronian and Keewatin of the Lake Superior region. They underlie much of southern Manchuria, northern Chihli, Shansi and considerable areas in Mongolia. They outcrop in the Shantung mountains, and in the Tsinling Mountains in Central China and Nanshan in the south there are areas of ancient rocks which it has been customary to correlate with the Archean, though just what part is truly of that age is not now certain.

Algonkian:—The correlatives of the rocks of this system as defined in the United States seem to be widely distributed in China. In part, they have been previously considered to belong to the Archean but mainly they were placed by Richthofen in the *"Untersinisch"* and regarded as Paleozoic in age. Willis separated them from the rocks above and below and described them with especial fullness as developed in northern Shansi. He called them the Huto but suggested their probable equivalence to the Nankow of Richthofen, a correlation since verified by Higgins. The rocks consist of a series of slightly altered quartzites,

slates, and siliceous limestones. Willis discriminated three series within the system but these have not been separated elsewhere. In general, all the pre-Cambrian has been mapped together. Many of the rocks are similar to the Upper Huronian of the Lake Superior country, others resemble the beds found in the Cœur d'Alenes and other pre-Cambrian areas in the western States. The pre-Cambrian as a whole is more widely distributed than is the Archean alone and outcrops in Manchuria, Mongolia, Chihli, Shansi and Kansu in the north, while in the south and west rocks supposed to be of this age are found from Fukien to Szechuan.

Cambro-Ordovician:—While careful stratigraphic and paleontologic studies permit separation of the Cambrian from the Ordovician in a few districts, the two are generally not distinguished but form one great system known as the Sinian. It consists dominantly of limestones and dolomites but includes also red and green shales which are more abundant in the lower part. The Sinian limestones may be generally discriminated in the field from those that are older by the presence of fossils, of gray and red oölites, and their prevailing darker color. They are also generally free from chert. The formation is thick and is widely distributed in central and northern China. In the south, it is more generally buried. There is in North China, marked unconformity at its top.

Silurio-Devonian:—Rocks belonging to both the Silurian and Devonian occur along the Yangtze and through the south but are generally absent in the north. They include green shales containing the "Trenton" fauna, thin limestones, and numerous sandstones. Much of the limestone and sandstone found along the lower Yangtze was referred to the Devonian by Richthofen. These rocks, where influenced by intrusive igneous rocks, are mineral bearing. Elsewhere they are not important from the present point of view.

Carboniferous:—Willis has pointed out that the Carboniferous strata in China constitute two distinct series, both of which however are of upper Carboniferous age, the Pennsylvanian of American geologists. The one found

mainly in the north, which contains most of the coal mined on a large scale in China, consists essentially of sandstone, shale, and coal but includes thin bituminous limestones. It is considered to be of continental origin. It extends over the northern provinces from Manchuria through Shantung, Chihli, and Shansi with an arm stretching down through Honan and Hupeh into Hunan. To the west, it is buried below later beds. The second division of the Carboniferous is found mainly in South China and consists essentially of a great limestone which attains a thickness of 400 feet. It extends westward from Anhwei and Kiangsi to Tibet and beyond.

Permo-Mesozoic:—To the south and west especially, the Carboniferous strata pass under a series of younger rocks which seem to represent the period from the Permian to the Jurassic. Apparently in Eastern Asia the Paleozoic and Mesozoic are not separated by a major break as in America and Europe. As seen in Eastern and Central China, the beds are mainly red sandstones and shales similar to the Red Beds of Western America. From near Peking on to the southwest border of Yunnan, Jurassic strata are found. These include coal beds as well as sandstone and shale. Several of the fields are of Jurassic age. The Red Basin of Szechuan is floored by rocks of this age. To the south in Yunnan the basalts, porphyries, and tuffs, which form a characteristic portion of the Permo-Mesozoic, become especially prominent though they are found widely also in other parts of the country, including Shantung, Chihli, and the Ningpo-Hongkong region of the Nanshan.

Post-Jurassic:—At the close of the period of Mesozoic deposition in China came a great epoch of mountain-building, at which time the main ranges were outlined. Apparently, it was also the period in which the main intrusion of the beds by igneous rocks occurred, though igneous activity continued at least into the Tertiary. In the Yangtze valley there is a wide area within which rocks of the diorite family have invaded the late Paleozoic beds and it is in connection with these intrusions that many of the important iron ore deposits occur. In Cretaceous times, according to Willis, most of Eastern Asia was reduced to a great

peneplain which was bowed up in Tertiary and Quaternary times to form the present mountains. Tertiary deposits are not common though found in China and the great Fushun coal bed in Manchuria is in the Tertiary. In Indo-China there are other coal fields belonging to the same period. Willis believed the mountains of China to be of very recent age and in the main he was doubtless correct. J. G. Andersson has, however, found certain beds deep in the gorge of the Yellow River which seem to call for some slight modification of Willis' views.

Coal is widely distributed in China and occurs in every province. The distribution of the fields is shown upon the small map reproduced herewith and based with slight modification upon one furnished by N. F. Drake with his report to the International Geological Congress in 1913. The principal change has been to extend the Pinghsiang field across the province of Kiangsi, to accord with present information, and to indicate a larger measure of discontinuity in the southern fields than was believed to be true when Drake made his summary. It will be noted that there are two large fields, one in the north and the other in the south. Neither is continuous, and in each case large areas of the coal measures are covered by later beds. In the south especially, the map indicates indeed the region within which small local coal fields occur rather than any continuous or even semi-continuous coal-bearing area. Outside these main areas, the coal fields appear small and scattered. This is in part a true representation, since the coal does occur in basins now isolated. Much of it is found in narrow belts fringing uplifted portions of older rocks. It is probable that if the loess and alluvium were stripped off, many of these individual fields would be found to be connected and undoubtedly many more were at one time continuous but have been separated by faulting and erosion.

Coal occurs at various geological horizons from the Carboniferous to the Tertiary. The most important and significant coal horizon is in the Permo-Carboniferous and is usually but a short distance above the older limestones, Sinian formation, upon which the coal measures were de-

posited. At or about this horizon has been found the bulk of the high grade coal so far mined in China. Still higher, in the Jurassic, there are numerous coal horizons and much good coal is mined. The Tertiary in Manchuria, and per-

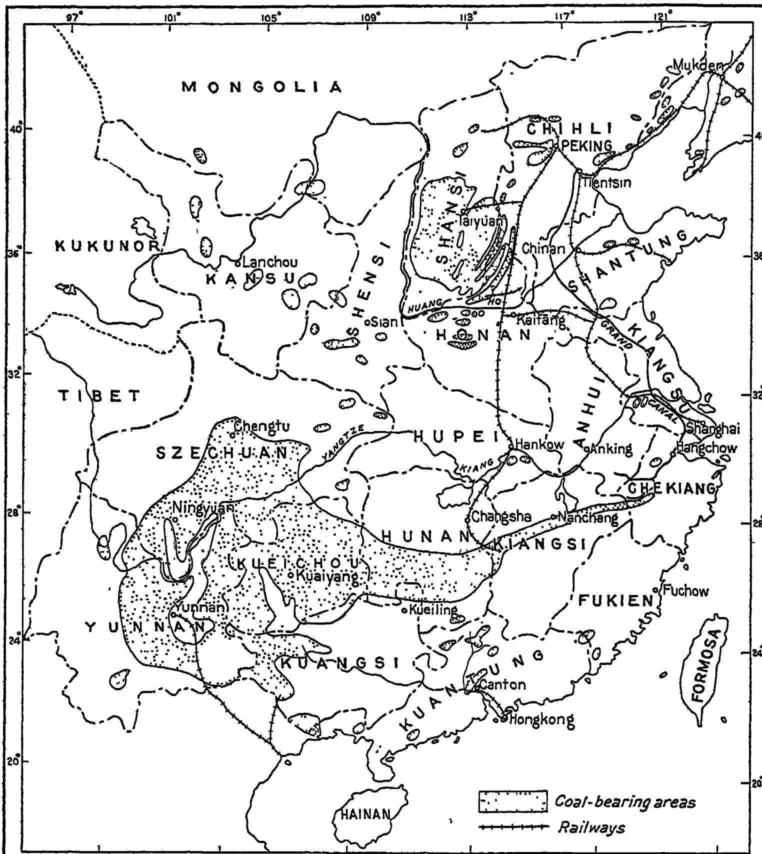

FIG. 5. *Coal fields of China in relation to railways and ports. The large areas indicated are not continuously coal bearing but are rather those within which coal is found.*

haps elsewhere, is characterized by enormously thick coal beds of limited extent and high volatile content.

China undoubtedly contains one of the world's great reserves of coal though there are wide variations in the estimates that have been made of the amount present. For

the report of the International Geological Congress in 1913 two estimates were submitted, one by N. F. Drake, an American geologist and mining engineer long resident in China, and one by K. Inouyè, Director of the Imperial Geological Survey of Japan. Both were printed in the "Coal Resources of the World" published by the Congress. Drake's estimate, which was the more complete of the two, is given below as condensed by him. In submitting it he made the following comment:[1]

> "The above estimates are sure, in many cases, to be far from correct, but it is believed that they will more often err in being too small than in being too large. It is very probable that the estimates given for the coal reserves of Kansu and Mongolia especially, are much too small, while the reserves attributed to Shansi, Kweichow and Yunnan may be somewhat too large. On the whole, we believe the data at hand fully justifies the statement that the coal reserves in China are at least as great as the total given above, and that future investigation will probably determine the real reserves to be much greater."

While Drake's figures are subject to serious reduction, as shown by W. H. Wong's estimates later given, they are

CHINA'S PROBABLE COAL RESERVE

(*Drake's Estimate*)

	Million Metric Tons
Mongolia	1,200
Chihli	22,668
Shantung	7,083
Shansi	714,340
Shensi	1,050
Kansu	5,129
Honan	9,275
Kiangsu	10
Anhui	187
Hupeh	117
Chekiang	24 7/10
Fukien	25
Kiangsi	3,395
Kwangtung	1,009
Kwangsi	500
Hunan	90,000
Szechuan	80,500
Kweichow	30,000
Yunnan	30,100
Total	996,612 7/10

1 "Coal Resources of the World," Vol. 1, p. 165, Toronto, 1913.

CHINA'S PROBABLE COAL RESERVE—*Continued*

(*Inouyè's Estimate*)

	Million Metric Tons
Chihli	3,080
Shangtung	650
Shansi	1,200
Honan	200
Chekiang	120
Fukien	80
Kiangsi	1,435
Hunan	17,000
Szechuan	15,000
Manchuria	800
Total	39,565

given here as illustrating accepted opinion at the time the present surveys of the region began.

The figures for Manchuria were presented separately by Inouyè. Besides the "probable" reserve in the various provinces listed, he allowed for additional but unestimated "possible" coal.

Commenting upon these two estimates in 1916, V. K. Ting, then Director of the Geological Survey of China, said:

> "The apparent discrepancy is explained by the fact that Drake attempted to make a complete estimate by summing up all known data, whilst Inouyè gave practically all that was known to the Japanese Geological Survey: hence, his estimates for Fukien and Chekiang, the two provinces best known to the Japanese, are higher than those given by Drake, although in all other cases his figures are much lower. The term 'probable reserve' used by Inouyè is somewhat misleading, as his figures suggest totally wrong ideas of the relative importance of the different provinces.
>
> "Drake's attempt is much nearer the truth though much of it is guess work. He himself remarked that the figures for Shansi, Yunnan and Kweichow might be too large. This is certainly the case. His source of information was chiefly Richthofen and Leclère. The former perhaps somewhat overestimated the coal resource of Shansi as he certainly did in the case of iron, and Leclère's work on Yunnan and Kweichow proved to be erroneous—a country much complicated by deep folding and faulting was supposed by him to be a simple plateau, hence his estimate must be many times too large. On the other hand, those for Chekiang, Fukien, Kiangsi, Anhwei and

Mongolia are all too small. In the case of the first two provinces, Inouyè's figures prove the point. The recent work of W. H. Wong shows that in Kiangsi the coal field of Pinghsiang stretches in the E.N.E. direction through the district of Fencheng and Loping to Fuliang in the northeast. This immense belt alone would give a reserve equal to that given by Drake for the whole province, and other smaller coal fields are also known in Kiangsi. The same worker shows also that in western Inner Mongolia the Jurassic coal amounts to over two billion tons. Both Inouyè and Drake gave very incomplete accounts of Anhwei. The numerous fields in northern Anhwei; namely, Shusung, Taihu, Shuchow and Hweiyuan, were apparently unknown to them, and the latter's description of southern Anhwei, taken chiefly from Ishii's report, is inaccurate and misleading. Again, no mention was made of Chinese Turkestan which contains at least as much coal as Kansu, its eastern neighbor.

"On the whole, however, Drake's total figure is certainly of the right order of magnitude though the figures for individual provinces are very uncertain. It is, in fact, futile to try to arrive at more exact conclusions as sufficient data do not yet exist, but it is correct to say that as far as present knowledge goes, 100,000 million metric tons is a fair minimum figure, but the real reserve is probably ten times as large. Taking the total production for the whole world to be roughly one billion tons per year, then China is probably capable of supplying the whole world with coal at the present rate for the next 1,000 years."

In the years since these estimates were made the staff of the Geological Survey of China has made extensive studies of a number of the coal fields and reports are now available in English upon several of them in the bulletins of the Geological Survey of China.[1] As a result of these studies and other data available to the Survey, the estimate

[1] The Coal Fields of Yu-Hsien. Yang-Yuan and Kuang-Ling, Chihli; Ting, V. K. and Chang, C. T. No. 1, 1919.
The Coal Fields of Ling-Yu-Hsien, Chihli; Yih, L. F. and Liu, C. C. No. 1, 1919.
The Coal Fields of Chang-Hsien, Northwestern Chekiang; Yih, L. F. No. 1, 1919.
On the Geology and Coal Resources of the Districts of Chia-An, An-Fu, and Yun-Hsin in Kiangsi; Wang, T. C. No. 2, 1920.
The Coal Field of Tatung, Shansi; Wang, C. C. No. 3, 1921.
The Coal Field of Lei-Yang, Hunan; Chu, T. O. No. 3, 1921.
The Geology of the Tsuchuan-Poshan Coal Field, Shantung; Tan, H. C. No. 4, 1922.
The Geology of the HoKang Coal Field, Heilungkiang; Tan, H. C. No. 6, 1924.
Geology of the Coal Fields of Chin Hsien and Hsuan Cheng, Anhwei; Yih, L. F. and Li, C. No. 6, 1924.
Report of the Chang Chiu Coal Field in Shantung; Andersson, J. G. No. 6, 1924.
On the Stratigraphy of the Tse Chow and Liu Ho Kou Coal Fields, on the Border of S. Chihli and N. Honan; Chao, Y. T. and Tien, C. C. No. 6, 1924.

presented below has been prepared and published by the present director, W. H. Wong.

CHINA'S PROBABLE COAL RESERVE[1]

(*Wong's Estimate*)

	Million Tons		
	Anthracite	*Bituminous*	*Total*
Chihli, including metropolitan districts	762	1,608	2,370
Mukden	35	950	985
Jehol	80	850	930
Chahar and Suiyan	150	310	460
Shansi	2,370	3,460	5,830
Honan	1,385	380	1,765
Shantung	30	655	685
Anhwei	70	135	205
Kiangsi	110	705	815
Kiangsu	...	190	190
Chekiang	50	70	120
Hupeh	70	60	130
Hunan	1,000	600	1,600
Szechuan	200	1,300	1,500
Shensi	...	1,000	1,000
Kansu	100	900	1,000
Amur	...	160	160
Kirin	...	160	160
Yunnan (including lignite)	...	1,200	1,200
Kweichow	...	1,300	1,300
Fukien	150	...	150
Kwangsi	...	500	500
Kwangtung	200	100	300
Total	6,252	17,183	23,435

Wong adds the following comment:

> "In all these reserves a depth to 1,000 metres is assumed and only seams with a thickness of one metre are taken into account; if we include thinner seams and increase the depth, it is probable that 40 to 50 billion tons would be a good figure for the total Chinese coal resources. This reserve will be sufficient to supply China 2,000 years if her present consumption of about 20 million tons per year is taken as the standard; but it will last only 70 years if we take as a standard the American annual output, which is 680 million tons."

The considerable discrepancy between this and the earlier estimates is at once noticeable, as also the fact that Wong considers the reserve to be hardly more than one-twentieth that estimated by Drake and given general approval by Ting. No later general estimates have been made,

[1] China Year Book, 1924, p. 124.

but individual fields have been studied and with few exceptions the amount of coal actually present has been found to be less than originally estimated.

In making up his estimates, Drake allowed 1,280 million tons for the actual reserve and 1,838 for the probable reserve in the Yi-hsien field in southern Shantung. The coal here is of excellent quality and makes a fine hard coke so that it has attracted considerable attention. There are a number of shafts open and a fine modern mine in operation. About 1915, the field was studied in a preliminary way by G. G. S. Lindsey, a Canadian mining engineer, widely experienced in coal mining. He made a tentative estimate of 150,000,000 tons of coal as the easily available reserve. I visited the field in 1917 and this seemed a reasonable estimate in view of the area as shown by outcrop and thickness as shown in the mines. When, however, the ground was prospected with diamond drills preparatory to opening an additional colliery, concealed faults and rapid changes in thickness of the coal bed were found, with the result that it was only after considerable drilling that a block of 20,000,000 tons of coal properly situated for mining was outlined though other blocks probably remain to be found by further drilling. Similar experiences from drilling in Anhwei and other provinces might be cited and possibly they have unduly influenced opinion.

Probably the largest and most valuable coal field in China is that which is found in Shansi and extends west across Shensi and into Kansu, outlined in fig. 6. New estimates of the reserve in this field have just been made available by Fuller and Clapp[1] as a result of numerous geologic cross sections and over 8,000 miles of reconnaissance made in preparation for oil well drilling. Richthofen had originally estimated the east Shansi fields (anthracite) to contain 630 billion tons of 2,000 pounds each and considered the bituminous coal field as equally extensive. Drake revised Richthofen's figures for eastern Shansi and reduced the total to 350 billion tons. He did not estimate

1 "Revision of Coal Estimate for West Shansi, China." M. L. Fuller and Frederick G. Clapp. Economic Geology, Vol. XXI, pp. 743-756, December, 1926. Also, "Coals of Shensi and Kansu, China." M. L. Fuller and Frederick G. Clapp, *idem*, Vol. XXI, January, 1927.

the reserve in the western field. It is the latter that was studied by Fuller and Clapp. In making their estimates various assumptions were made as to average thickness, persistence in depth, and extent under cover. They calculated the probable reserve in this particular field to be 210 billion tons, of which 128 are in the North Shensi basin and 82 in the down-faulted and broken ground between the Fen-ho and Yellow River (Hwang-ho) in western Shansi. In place then of the original 1,260 billion tons estimated

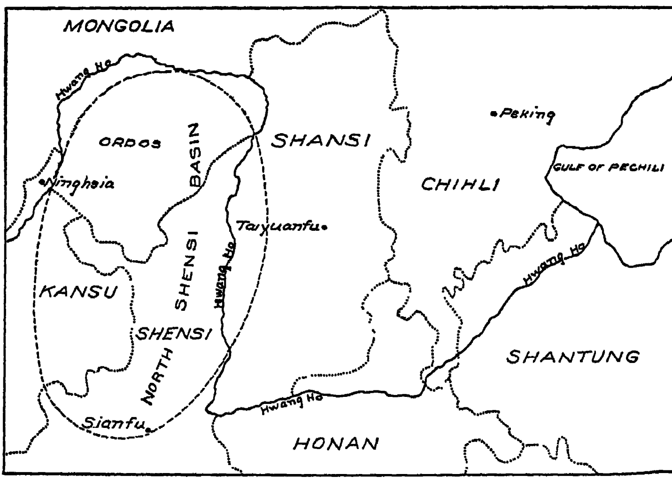

FIG. 6. *Sketch map showing Shansi and Shensi coal fields. After Fuller and Clapp. From "Economic Geology" by permission.*

by Richthofen, we now have Drake's estimate of 350 billion for East Shansi and Fuller and Clapp's figure of 210 billion for the western field. To these figures may be added C. C. Wang's estimate[1] of 1,350 million tons as the reserve in the Tatung field to the north, now known to be separate and indeed of later age, making a total of a trifle over 561 billions as against the original estimate of more than twice as much.

For the whole of the region, however, Fuller and Clapp make a much higher estimate than either Wong or Drake and they have, quite certainly, a more detailed knowledge of the region besides being well qualified engineers expe-

1 Bull. Geol. Surv. China, No. 3. Oct., 1921.

rienced in the survey of coal fields. Their general summary is quoted below entire:

"The total recoverable tonnages of the coals of the North Shensi Basin are summarized in the table below. Under recoverable coal is included that which is not beyond the depth of practicable mining, although much of it will probably never be actually removed from the ground. The non-recoverable coal is that which will not warrant removal under normal conditions, although much could be recovered if its value warranted unusually deep mining. The term basin in the first column refers to the North Shensi Basin. All figures are in tons of 2,000 pounds each, and are necessarily merely approximations.

SUMMARY OF COALS IN NORTH SHENSI BASIN

	Permo-Carboniferous Coals				*Jurassic Coals*					
Province	*Recoverable*		*Non-Recoverable*		*Recoverable*		*Non-recoverable*		*Total Coals (Overlapped)*	
	Area (Sq. m.)	*Tons (Billions)*	*Area (Sq. m.)*	*Tons (Billions)*	*Area (Sq. m.)*	*Tons (Billions)*	*Area (Sq. m.)*	*Tons (Billions)*	*Area (Sq. m.)*	*Tons (Billions)*
Shansi										
Basin	5,600	128	0	0	0	0	0	0	9,000	210
Graben	3,400	82	0	0	0	0	0	0		
Shensi										
Basin										
East	2,500	58	29,500	560	4,500	53	10,000	64	36,000	781
South	2,000	23	(whole basin)							
Graben										
South	2,000	23	0	0	0	0	0	0		
Kansu	1,250	15	22,750	280	0	0	10,000	117	24,000	412
Mongolia	3,500	41	27,500	540	2,500	30	10,000	86	31,000	697
Totals	20,250	370	79,750	1,380	7,000	83	30,000	267	100,000	2,100

"It is frankly admitted that many factors are incompletely known, this being especially true of the thicknesses which vary widely from place to place and are seldom definitely known even at a single point. The heavy cover of loess enters materially into the problems of area, preventing the determination of the limits of the graben 'basins' as well as modifying the extent of recoverable areas. While thousands of miles of traverses were run within the 100,000 square miles of the basin, there are several comparatively broad stretches of unvisited territory, some being as much as 50 miles in width. Of these, there are no available maps except of the most general type, and conditions can only be judged by inference."

The following table will serve to illustrate how far apart are the various estimates of the reserves in the four provinces, though they are not on exactly the same basis. For convenience, the figures have all been reduced to units of one million metric tons. The estimate is for the presumably recoverable coal.

COMPARISON OF ESTIMATED COAL RESERVES OF CHINA

	Drake	*Inouyè*	*Wong*	*Fuller and Clapp*
Shansi	714,340	1,200	5,830	190,909
Shensi	1,050	...	1,000	132,727
Kansu	5,129	...	160	13,636
Mongolia	1,200	...	460 [1]	71,000

It is impossible with known data to reconcile these estimates and it would hardly be worth while to review the fragmentary knowledge of other individual fields that is available. It should be remembered that all the general estimates are based upon approximate measurements only of the area of each field multiplied by some figure believed to represent the average thickness of the coal. The total so obtained has been reduced in each case by some percentage, determined by the experience of the engineer making the estimate, to bring it down to the tonnage that may be taken as recoverable. It is a matter of difficulty to determine correct averages for use in such calculations and in advance of actual prospecting by drill or shaft, the extent of the coal under cover can only be inferred. The coal fields of the Yunnan plateau were at first thought to be continuous over a large area. The plateau is now known to be broken and faulted and the coal fields to be individually small and scattered. A number were examined in 1920 and it was clear that any general estimate of tonnage might well be extremely deceptive. It may none the less be taken as reasonably certain that the Shansi-Shensi coal fields rank among the richest in the world and that China as a whole holds one of the great coal reserves. It will probably not lead to great error if for present purposes Drake's general estimate be accepted as being of the right order, however it may be out in particular details. The presence of this large coal reserve is a fact of first importance to the

1 Chahar and Suiyuan only.

future industrial history of China and the Far East generally.

As yet, the fields are but little developed, nor can they be without a great change in conditions as regards transportation and industry. The extent and character of the present coal mining industry may be inferred from the fol-

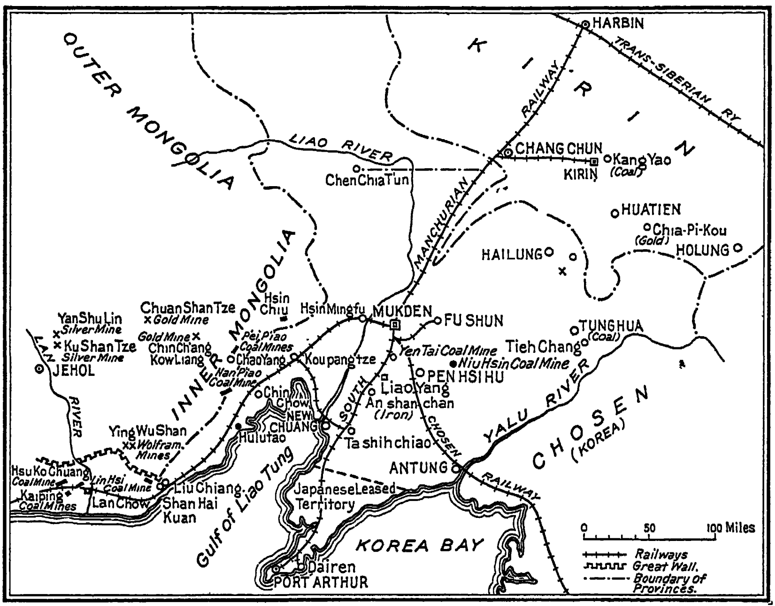

FIG. 7. *Map showing coal fields, railways and metal mines of South Manchuria, inner Mongolia and part of Chihli; after W. F. Collins. The Kaiping coal mines are those of the Kailan Mining Administration.*

lowing tables taken from W. H. Wong's report in the China Year Book for 1925.

Allowing six to seven millions as the probable output of native mines, W. H. Wong gives the following as the total coal production of recent years, the figures being in metric tons.

COAL PRODUCTION OF CHINA

1912............	13,000,000	1918............	18,033,000
1913............	14,000,000	1919............	19,387,000
1914............	15,000,000	1920............	20,381,000
1915............	15,440,000	1921............	19,872,000
1916............	15,584,000	1922............	19,954,000
1917............	17,205,000	1923............	22,681,000

PRINCIPAL COALS PRODUCED IN CHINA[1]

Coal Basin	*Principal Mining Company*	*Capacity of Production Per Yr. in 1,000 Tons*	*Moisture*	*Volatile*	*Ash*	*Sulphur*	*Coke*	*Nearest Sea or River Port*
Kaiping	Kailan Mining Adm.....	5,000	0.68	21.03	10.52	0.96	Cokes	Chingwanta, Tientsin
Lincheng	Lincheng Mining Adm...	300	1.12	30.73	11.60	1.27	Cokes	Hankow, Tientsin
Chinghsing	Chinghsing Mining Adm.	800	0.89	27.97	9.64	1.45	Cokes	Hankow, Tientsin
Fushun	Fushun Coal Mine......	6,800	6.58	37.85	1.92	0.43	Non-coking	Dairen, Yinkow
Penhsihu	Penhsihu Mining Co.....	400	0.56	23.38	7.07	0.48	Cokes	Dairen, Antung
Tsuchuan and Po-shan	Lutao Mining Co. and others	1,300	0.88	13.47	7.31	0.89	Cokes	Tsingtao
Yihsien	Chunghsing Mining Co..	800	0.10	26.80	9.82	0.50	Cokes	Pukow
Anyang	Liuhokou Mining Co.....	500	1.33	13.35	10.35	1.06	Cokes	Hankow, Tientsin
Hsiuwu	Fuchung Corporation....	1,300	2.90	6.05	9.88	0.41	Non-coking	Hankow, Tientsin
Pinghsiang	Pinghsiang Mining Co...	900	1.35	23.72	13.92	0.45	Coke	Hankow, Tientsin
Tatung	Several companies......	400	3.78	25.51	6.20	....	Non-coking	Tientsin

[1] "China Year Book," 1925, p. 124.

The table includes substantially all the known coking coals now produced. There are many more beds that do not coke than do. At the Kailan mines, for example, only the smaller portion of the reserve is formed of coking coals and steam coal furnishes the main output. The table also fails to reflect the relatively large amount of anthracite coal since little of it reaches the general market.—H. F. B.

The civil wars have interrupted production, particularly by interfering with transportation, but Julean Arnold, American Commercial Attaché, estimates the production in 1925 to have been 25,000,000 tons.

The largest coal enterprises in China are those of the Kailan Mining Administration at Tangshan in Chihli, and the Fushun collieries of the South Manchuria Railway near Mukden. Both are highly successful enterprises, but both find their larger market outside China. The Kailan mines supply a variety of coals including coking, naval fuel, steam and domestic. The Fushun coals do not naturally make a firm coke, but by mixture with other coal a satisfactory product is made and used in Japanese furnaces in Manchuria and Japan. The coal field which is the basis of the Kailan operations has been described by a number of engineers and geologists. The papers by H. C. Hoover [1] and N. F. Drake [2] will be found especially complete. The Fushun field has been described by W. A. Moller [3] and by K. Inouyè.[4] It is notable for the presence of a thick bed, usually 130 to 200 feet, which lies so as to be available in part for the steam shovel mining. The coal is also worked by underground shafts. At the main workings the area that has been drilled is estimated to contain 282,000,000 tons of proved coal and 260,000,000 tons of probable coal. There is an additional amount to be won from other points, but the total is not accurately known. The coal is of Tertiary age and in "Mining in Japan" the following is quoted as the analysis:

	Percent
Moisture	5.71
Volatile	40.63
Fixed Carbon	53.65
Ash	3.89
Sulphur	0.53
Nitrogen	1.60

T. T. Read gave, in the "Coal Review" for March 9, 1921, an account of a visit to the property as well as an interesting discussion of modern coal mining in China.

1 "Kaiping Coal Mines and Coal Field, Chihli Province, North China," Trans. Inst. Min. and Met., Vol. X, p. 419. London, 1901-02.
2 "The Coal Fields of Northeastern China," Trans. A. I. M. E., Vol. XXXI, p. 492, 1901.
3 "The Fushun Colliery, South Manchuria," Trans. A. I. M. E., Vol. XLI, pp. 241-242, 1910.
4 "Coal Resources of the World," Vol. I, pp. 267-272.

In the various reports already cited, especially the volume on the "Coal Resources of the World," will be found descriptions of the individual coal fields in China and other Far Eastern countries. It is scarcely necessary to review them in detail. It is evident that China possesses an abundant supply of this most useful mineral, though with her large population she will have use for great quantities if there comes to be a major change in the habits of her people. China's reserve is all the more important since it is only in that country that any considerable supply of coking coal is known in the Far East. Even so the known fields of good coking coal are not numerous. In Manchuria the Penhsihu field stands out.[1] In Northern Chihli, the Kaiping coal, the Peipiao and perhaps others will coke. In southwestern Chihli, the Liuhokou coal especially has a good reputation for coking. In Shantung, the Yihsien and other coals coke and in Honan, Kiangsi, Hunan, Yunnan and other provinces, coking coal is found. It is true here, however, as elsewhere that coking coal is exceptional. Anthracite, of which there are large quantities available, can be used as a metallurgical fuel, though with less efficiency, and in general any large metallurgical industry in the Far East will necessarily depend upon Chinese reserves of coking coal if it is to persist.

At present, the largest demand for coal in China is doubtless for household purposes, despite the extremely small per capita consumption. If the Chinese ever should come to use coal as freely in their homes as do the English and Americans, the output would need to be multiplied at least 15 times without regard to increase for other purposes, such as for transportation, without which the greater amount of household coal itself could not be mined and delivered. The factory system has made relatively little progress in China, so that there are few industrial centers calling for large amounts of coal. Shanghai is perhaps the most important and absorbs something over 1,250,000 tons per year, of which about one-half is used for bunkering ships. Peking requires about 1,000,000 tons per year, mainly for household heating. Another considerable center of consumption

1 C. F. Wang, Trans. A. I. M. E., Vol. LIX, p. 395. 1918.

is Hankow where coal is in demand for use in the Hanyang Steel Works, for the river boats, for locomotives, and a constantly increasing group of factories. No figures are available showing the entire consumption of the district but much the larger part of the coal mined at Pingshiang is marketed at Hankow, and there are also important shipments from the north by rail and from various other directions by water. Canton in the south affords a market for about 200,000 tons annually. Over the country as a whole, household burning alone requires but 0.006 tons per capita as compared with the usual 1.1 tons in America. In New England the total per capita consumption is 7 tons, and in Chicago it is 8 to 9 tons a year. From any point of view, the coal market of China is largely undeveloped and it may be expected to grow steadily. It does not follow that intensive production at any one point will not swamp the existing market tributary to it. Indeed, more than once in the past collieries in China have suffered because of overproduction.

The physical conditions are not generally favorable to mining in the Chinese coal fields. The coal occurs largely along the flanks of the mountain ranges and in rocks that have been much faulted and in part invaded by igneous intrusions. As a result of the disturbance of the strata, it is not only necessary to prospect carefully in planning mines, but to do considerable dead work per ton of coal. Another difficulty is that the faults traversing the rocks let underground water into the mines and increase danger and pumping expenses. It happens in several of the fields that the most important coal beds lie but a short distance above limestone beds which, either as a result of exposure to erosion before the coal was formed or to later cracking, have become cavernous and so are enormous water reservoirs and that as a result of folding it may be necessary to cut into them. At various collieries disastrous floods have broken into the mines. Another difficulty is due to the presence of numerous unmapped old workings which are most irregular and extensive and which by reason of the cracking of the overlying rocks are full of water. To drain them would mean to pump out the whole countryside and in the absence

of exact knowledge of the position of fault planes, barrier pillars have not always proved effective. As illustrating how serious the pumping problem may become, it may be mentioned that at one mine visited one-eighth of the output was consumed to furnish power for the pumps. This is an extreme case. At another colliery the portion of the coal so used was 1.37 percent. It is believed that with proper preliminary work this source of cost and danger can be controlled but it is no region for making short cuts in technology.

Neither gas nor dust have as yet proved generally troublesome, though there has been one serious disaster in the Fushun mines in Manchuria and another at Kaiping. As deeper mines are opened and worked, danger from these sources will doubtless become more common. Roof and floor conditions are not generally bad away from definite fault planes, but the scarcity and high expense of timber make it impossible to drive large rooms. This difficulty is increased by the fact that the coal beds are very commonly thick, at Fushun more than 200 feet, and satisfactory methods of working thick coal are rare anywhere. At Fushun, sand filling is practiced. At the mines of the Chung Hsing company and elsewhere, rock packing has been adopted, while at the Kailan collieries an ingenious caving system has been used with good effect. Powder is little used in the mines, the abundance of coolie labor leads to hand tramming as against mechanical haulage, and timber being scarce and expensive, brick and stone are largely used for underground support.

As to costs of mining it may be said that while the apparent first cost of mining coal in China is low, the actual cost is about the same as with good work in America when equal annual tonnage are handled, despite the more difficult mining conditions. The best cost realized in China, which is attained by a well-run company of large output and long history, is low even compared with American standards, and the larger coal companies have shown considerable profit which is not surprising in view of the high prices so far generally obtained for their product.

As already indicated, the largest known or probable re-

serves of coal in the Orient are to be found in China, and the other countries show generally a deficiency if account be taken of their population and possible future needs. There are, however, fields that are of special or local importance.

Siberia: Coal is mined near the Pacific coast in the vicinity of Vladivostok and on the Island of Sakhalin. The Suchan field was opened during the Japanese-Russian war to furnish coal for the cruisers imprisoned in Vladivostok harbor. It has not been completely developed, but Russian geologists consider that it is capable of yielding a few million tons. Most of the coal in the vicinity of Vladivostok is high in ash and of low grade, but from Suchan coal of good steaming quality is mined. The best quality of coal available in Eastern Siberia comes from Northern Sakhalin, being shipped through the port of Alexandrovsk which is closed part of the year by ice. Near the coast here, and in the Tertiary beds, are several workable beds of coal of excellent quality. The field extends for 100 miles along the coast and about twelve miles inland. The Russian geologists estimate the probable reserve at 500,000,000 tons and this figure is at least in part confirmed by measurements and studies made by Ross Hoffman and R. Smith, American engineers who have examined and sampled the deposits. Having in mind the many disappointments resulting from estimates based on surface mapping, and the irregularity that characterizes Tertiary coal beds in particular, the estimates should be confirmed by drilling. As to the quality of the coal there is no doubt. Both for steam use and for coke making it ranks high and the amount available is undoubtedly large.

Japan: The estimated reserve as determined by the Imperial Geological Survey in 1913, has already been stated to have been 8,051 million tons, including the coal in Korea. If to this be added the known reserve in Manchuria, which is available to the Japanese and most of which is already dominated by them, the total becomes 9,251 million tons. In proportion to population and probable needs this is not large, though as to fuel Japan is better provided than Italy, for example, which has about

the same population and in many particulars faces the same industrial problems.

According to a recent summary prepared by G. Kobayashi of the Imperial Geological Survey,[1] coal is known to occur in the Paleozoic, the Mesozoic and the Tertiary, and may be classified as (1) anthracite and semi-anthracite, (2) bituminous and sub-bituminous coal, (3) black lignite and (4) lignite. The coal in the Paleozoic and the Mesozoic belongs to the anthracite and semi-anthracite varieties; that in the lower Tertiary, considered as the Eocene and Miocene age, is mostly bituminous and sub-bituminous coal and black lignite; while that in the upper Tertiary, probably the Pliocene, is lignite. The Omine and Tsubuta coal fields are important occurrences in the Jurassic; the less well known Bitchu are in the Triassic and the Tamba in the Jurassic. The most important coal seams are in the Tertiary, the coal fields of Kyushu and Hokkaido being the most extensive and valuable in Japan.

As regards coal reserves, the Ishikari coal field ranks first; while as to production the Chikuho coal field leads. The center of coal production is in Northern Kyushu, which yields about 60 percent of the total output of Japan. Of the coal fields in Northern Kyushu, the Chikuho coal field is the largest and yields about 72 percent, while the famous Miike coal field ranks next both in respect of its coal reserves and its output. The Karatsu, Sasebo, Sakito, Matsushima and Takashima fields are also important and yield good bituminous coal. In Hokkaido, the coal-mining industry is in course of development, so that the output is rather small in comparison with the reserves. The Joban coal field, extending over Hitachi and Iwaki, ranks next to those of Kyushu and Hokkaido, but the coal is much inferior in quality and less in quantity. The coal fields in the southern part of Nagato, known as the Ube coal field, are of much less extent and the coal is also inferior in quality. The other coal fields scattered throughout the country and yielding varieties from bituminous coal to black lignite, are less important both in reserves and output. The only Tertiary

1 "The Geology and Mineral Resources of the Japanese Empire," Tokyo, 1926, pp. 96-98.

coal fields yielding anthracite and semi-anthracite lie in Kii and Higo, both the output and reserves being small. Lignite-bearing Tertiary is scattered throughout central and northeast Japan, though its extent is limited. The coal fields extending over Owari and Mino, known as the Nobi coal field, yield lignite and are the most important of the lignite districts. The coal fields in the northern part of Taiwan are the only source of coal in Taiwan, the production exceeding the demands of the island. The coal fields of Karafuto are considered to contain a large amount of coal but they are not thoroughly explored. Only two, the Naibuchi and Notoro fields, have been even roughly surveyed. Most of the coal fields in Karafuto or southern Sakhalin have not yet been opened, so that the annual output of coal is very small.

In quality the coal in Japan varies from anthracite to lignite, but the great bulk of the reserve consists of bituminous coal, mainly of high to medium volatile type. Both coking and free-burning coals are found, but the amount of coking coal is, as usual, limited and the smallness of the reserve has given some concern. In practice, coking coal is imported from China to supplement the local supply, though the country is by no means entirely dependent upon such imports.

Kobayashi gives the analyses in the following table as typical.

The coal fields have been carefully studied by the Imperial Geological Survey and the then Director, K. Inouyè, presented to the International Geological Congress in 1913 a careful summary of the results[1] illustrated by numerous maps and sections and containing detailed estimates and analyses. In 1921, the Survey printed a coal map of the Empire giving the geology of each field and indicating by symbols the estimated reserve in each. While these later figures show some increases as to particular areas, the agreement is close and either may be used by those desiring details.

Coal mining is an ancient industry in Japan, though it has only been since the Restoration that there has been need for more than a very moderate amount of coal. Promptly

1 "Coal Resources of the World," Vol. I, pp. 279-348.

COMPOSITION OF JAPANESE COALS

Age	*Locality*	*Kinds of Coal*	*Moist.*	*Volatile Matter*	*Fixed Carbon*	*Ash*	*Sulphur*	*Calorific Power*	*Sp. G.*
Upper Trias	Omine (Nagato)	Semi-Anthracite	3.04	8.74	68.74	19.48	0.62	6042	....
Eocene	Naibuchi (Karafuto)	Low grade Bituminous	5.12	43.35	40.84	10.69	0.33	6209	1.336
Eocene	Bibai (Ishikari)	Bituminous	3.25	39.49	47.90	9.36	0.38	7024	1.335
Eocene	Horonai (Ishikari)	Bituminous	4.56	41.63	49.14	4.57	0.49	6655	1.311
Eocene	Yubari (Ishikari)	Bituminous	2.28	41.20	50.41	6.11	0.44	7371	1.284
Miocene	Kushiro (Kushiro)	Bituminous	7.54	39.60	45.30	7.56	0.35	5957	1.352
Miocene	Joban (Iwaki)	Black lignite	10.83	41.76	35.98	11.43	1.58	5476	1.349
Eocene	Onga (Chikuzen)	Low grade Bituminous	2.38	40.99	47.79	8.84	0.94	7017	1.317
Eocene	Fukuoka (Chikuzen)	Bituminous	3.00	42.03	47.29	7.68	1.07	7130	1.324
Eocene	Miike (Chikugo)	Bituminous	0.68	40.07	48.08	11.17	3.61	....	....
Eocene	Karatsu (Hizen)	Bituminous	3.40	42.17	45.39	9.04	2.08	6874	1.332
Eocene	Takashima (Hizen)	Bituminous	1.19	38.34	52.44	8.03	0.67	7110	1.348
Eocene	Amakusa (Chikugo)	Semi-Bituminous	2.65	11.75	78.88	6.83	1.60	6780	1.480
Miocene	Kürun (Taiwan)	Low grade Bituminous	4.36	38.08	54.28	3.28	4.16	6875	1.240

The above table includes analyses selected as representative by the Imperial Geological Survey of Japan. The Miike and Yubari collieries furnish coking coal, though the larger part of the output from these as from the others is used for steam making. The Takashima coal has long been in especial demand for bunkering ships and the Ishikari mines supply gas coals.—H. F. B.

upon the Restoration the Takashima shaft was sunk, under direction of a foreign engineer, and modern mining began. The situation of the Chikuho field at the cross-roads of eastern marine traffic, and the excellent quality of the coal mined, led to rapid development first of this and other Kyushu fields, and later those of Hokkaido and other islands came into production. Now coal mining is not only the largest element in Japan's mineral production, but the Japanese coal industry is the largest in the Far East. The output for recent years in metric tons with the value in yen is given below:

COAL OUTPUT OF JAPAN

Year	*Tons (Metric)*	*Value (Yen)*
1912	20,043,771	62,947,233
1913	21,763,405	72,751,342
1914	22,834,121	82,230,880
1915	21,126,862	67,622,809
1916	23,639,287	83,498,739
1917	27,287,398	144,407,259
1918	29,124,263	294,096,684
1919	32,712,981	455,386,752
1920	30,828,071	433,376,965
1921	27,675,872	240,512,784
1922	29,481,059	265,221,322
1923	30,941,184	272,529,937
1924	32,213,352	257,990,172

The larger part of the coal produced is consumed within the country, though there is a considerable export trade, particularly in the bunkering of steamers. The largest individual colliery is the Miike belonging to the Mitsui Company and now producing 1,800,000 tons per year. It is a fine modern plant and produces both steaming and coking coal from the Tertiary in Kyushu. The Onoura colliery in the same prefecture produces 1,300,000 tons, and the Yubari on Hokkaido puts out 1,100,000. These are the three largest mines though there are nine others each producing a half million or more.

The principal coal fields in Korea are at Heijo and Kainei. The former mines are anthracite of Paleozoic age and the latter a Tertiary lignite. The fields are not of more than local importance.

Philippine Islands: According to W. D. Smith[1] some coal is found on virtually every large island of the archi-

[1] "Geology and Mineral Resources of Philippine Islands," p. 366.

pelago, but there are only six important localities. These are: Batan Island; Gotas-Butong, Mindanao; Cebu Island; Polillo Island; Mindoro Island; and Masbate Island. For details regarding any of these, the reader may turn to the original report or to F. A. Dalburg's summary cited below. The Spanish authorities had done little to develop the coal, but soon after the American occupation vigorous efforts were made to find and produce a supply. A general report on the "Coal Measures of the Philippines"[1] was compiled by Lieut. Charles H. Burritt, and from 1904 to 1910 the United States Army attempted to mine coal at Lignan on Batan Island. When the Bureau of Science was organized, surveys of the coal fields were at once taken up and the results have been summarized in the report by Smith just cited and in another made by F. A. Dalburg to the International Geological Congress in 1913.[2] Dalburg, who studied a number of the fields, was later in charge of development of mines there and has also had experience in coal mining elsewhere. He has kindly checked and approved the following estimates of reserve originally prepared by him for the Congress:

ESTIMATE OF PHILIPPINE COAL RESERVES

Locality	Type	TONNAGE Actual	Probable	Possible
East Batan	Lignite	3,340,000	20,960,000	Moderate
Lignan	Sub-bit.	61,600	216,000	Small
Calanga	Lignite		2,560,000	Moderate
Camugumayan	Sub-bit.		14,592,000	Small
Camansi	Sub-bit.		4,505,600	Small
Mt. Licos	Sub-bit.		5,352,000	Small
Uling	Sub-bit.	800,000	4,992,000	Small
Burdeus	Bitum.		1,331,200	Small
Cataingan	Sub-bit.		612,000	Small
Sibuquey	Bitum.		3,628,000	Small
Bulalacoa	Lignite		4,096,000	Small
Sugud	Sub-bit.	154,000	......	
	TOTAL	4,355,600	61,980,800	

He states further that any estimate of the coal resources in tonnage will necessarily indicate the minimum quantity and cannot show the ultimate coal resources of the archi-

1 Report to U. S. Military Governor of the Philippines, 269 pages. Govt. Printing Office, Washington, 1901.
2 "Coal Resources of the World," Vol. I, pp. 107-122.

pelago. Even where surveys have been made, a large factor of uncertainty exists, as the coal-seams dip at all angles up to 90° and the seams are folded and faulted. Numerous seams have been known to thin out and disappear, and there is a great lack of knowledge regarding the sequence of the strata. The areas used in making the estimates are small and may possibly be greatly extended in the light of subsequent information.[1]

The fields are all limited in extent and are scattered. Their total known area was found by Dalburg to be 53 square miles, of which less than 7 square miles was definitely known to be coal-bearing. The coals are of Tertiary age, probably having been formed in the Miocene and corresponding in this particular to those of Japan. Lignite, sub-bituminous and bituminous grades are all found, the first at the greater distance from lines of uplift and the best coals being near the bases of the mountains, or where the beds have been folded. Their situation is such that they are much broken and faulted and the beds show the individual lack of persistence characteristic of Tertiary coals. Mining has proved both difficult and expensive. Smith quotes a cost of 13 pesos per ton as the minimum, the data having been furnished to him by a coal-mining engineer, as of June, 1921. Coal mining has as yet not proved to be a particularly successful business in the Philippines, the largest output reached by any colliery having been of the order of 200 to 400 tons per day at the mines of the Philippine Coal Mining Co., on Batan. The coals are friable, high volatile, and essentially non-coking, although a few samples have shown a slight tendency to coke. The lignite coals are difficult to store because of a tendency to spontaneous combustion.

The fuel value of the best Philippine coals is from two-thirds to three-fourths that of the best Cardiff coals, a little short of that of the Australian coals, but equal to that of many of those from Borneo and Japan.

The development of Philippine coal mining has been slow and it is even now unimportant, as is shown by the figures in the following table:

1 "Coal Resources of the World," pp. 113 and 114, Vol. 1.

COAL PRODUCTION IN THE PHILIPPINES

	Metric Tons (Estimated)
1852-1906 [1]	30,000
1907 [1]	4,123
1908 [1]	10,035
1909 [1]	30,336
1910 [1]	27,969
1911 [1]	32,000
1912 [2]	3,000 (—) [3]
1913 [2]	No production of economic value
1914 [2]	No production of economic value
1915 [2]	No production of economic value
1916 [2]	No production of economic value
1917 [2]	5,723
1918 [2]	15,593
1919 [2]	32,745
1920 [4]	58,888
1921 [5]	39,000
1922 [5]	41,000
1923 [5]	42,000
1924 [5]	47,278
1925 (1st 6 mo.) [5]...	29,830

With a production of about 60,000 tons per year, the Islands still import more than 500,000 tons annually from Japan, China and Australia. That coal is present in beds of mineable thickness and of fair quality is evident, but the conditions under which it occurs, coupled with the political and industrial conditions in the Islands, make it improbable that any large low-cost mining industry will be established. Any thought that the coal supply is adequate to the development of a metallurgical industry based on the iron ores of the Islands must be abandoned.

Netherlands East Indies: Coal is known at a number of localities in the archipelago and there are reasons for belief that the amount present is large, but as pointed out by E. A. Douglas,[6] there has as yet been no sufficient profit in sight to warrant accurate surveys of the fields. The coal is of Tertiary age and the bulk of it is referred to the Eocene. It is a high volatile, long-flame, non-coking steam coal, save in a few places where intrusive igneous rocks have altered its

1 F. A. Dalburg, Philippine Islands, p. 123, Vol. I, "Coal Resources of the World."
2 Coal, Coke and By-products (1913-19), p. 159. Part III. Imperial Mineral. Resources Bureau. H. M. S. O. Lond. 1922.
3 Sudden decrease due chiefly to flooding mine of East Batan Coal Co., and to wrecking by a typhoon of surface plant of Camasi mine in Cebu, *Ibid.*, p. 157.
4 Mineral Industry, p. 143, 1923.
5 Mineral Industry, p. 174, 1925.
6 "Coal Resources of the World," Vol. I, pp. 95-101.

character and raised the grade. In the table following are such estimates of reserves as Douglas was able to make.

COAL RESERVES OF THE NETHERLANDS EAST INDIES [1]

	Actual Reserve (*Metric Tons*)	*Probable Reserve* (*Metric Tons*)	*Possible Reserve*
SUMATRA			
Government Atjeh..........	....	....	Unknown
Res. Tapanoeli-Nias.........	....	....	Small
Government West Coast of Sumatra	....	294,000,000	
Res. Benkoelen.............	....	3,000,000	
Res. Districts of Lampong..	....	....	Unknown
Res. Palemband............	....	400,000	Very large
Res. Djambi................	....	....	Very large
Indrigiri	....	....	Unknown
Res. East Coast of Sumatra.	....	250,000	Unknown
JAVA			
Res. Bantam................	....	6,000,000	Unknown
Res. Batavia................	....	....	Small
Res. Pr. Regenschappen.....	....	....	Small
Res. Djokjacarta............	....	1,000,000	
Res. Remdang..............	....	700,000	
BORNEO			
Res. West Borneo..........	....	....	Unknown
Res. West Borneo			
Division Matapoera.......	31,800,000	....	
Tanah Boemboelanden....	300,000,000	....	
Koetei	443,000,000	337,000,000	
Doeson Landen...........	....	....	Unknown
Berausche Landen........	....	....	Unknown
Goenoeng Sawar..........	....	....	Very large
Tidoengsche Landen......	....	....	Unknown
Celebes	....	....	Unknown
Moluccas	....	....	Small
New Guinea..................	....	....	Very large
Total	774,800,000	642,350,000	

H. A. Brouwer [2] adds a few notes of interest pointing out that the two largest Eocene fields are those of Ombilin in the highlands of Padang, Sumatra, and the Eocene area of south Borneo. The Ombilin field extends 6 miles in a north-south direction and 5½ east to west. Beds as much as 25 feet thick are worked and in the southerly portion alone 144 million tons of coal is estimated to be present. Miocene and Pliocene coals are also known in Palembang, where a slow metamorphism has taken place, producing a coal of 7,000 to 8,500 calories heating value. In various parts of the island coals are indeed found ranging from

1 E. A. Douglas, "Coal Resources of the World," Vol. I, pp. 102-105.
2 Geol. N. E. I., pp. 127-133, New York, 1925.

anthracite with but 8 percent volatile matter to bituminous coals with 50 percent volatile.

The production since 1912, so far as figures are available, is given in the table below:

COAL PRODUCTION IN THE NETHERLANDS EAST INDIES[1]

	Metric Tons
1912	622,669
1913	453,136
1914	440,905
1915	400,000[2]
1916	......[3]
1917	......[3]
1918	......[3]
1919	949,379
1920	1,095,718
1921	1,212,665
1922	1,032,310
1923	1,156,625
1924	1,470,362

Indo-China: Anthracite is found near Haiphong in Tonkin and is mined at Hongay to the extent of about 300,000 tons per annum. The coal is of Mesozoic age, is dry and friable, and is marketed largely as briquettes. It is mined in a great open pit and constitutes one of the important resources of the colony. H. Latenois estimated[4] the reserve at 20 billion tons and whether or not this be exact it seems clear that there is here a large body of valuable coal.

Malay States: At Rawang in the Federated Malay States a black lignite coal is mined from a small basin of Tertiary rocks. The coal is non-coking but of fair steaming value. The bed is thick, more than 25 feet, and the dip is not too steep for cheap mining. The total amount present is not known but cannot be enough to be of more than local importance.[5]

Siam: Small areas of coal are known in this country at a number of points, but there is no reason to anticipate the discovery of any large coal fields.

1 Mineral Industry, Annual, 1916 to 1925.
2 Estimated.
3 Not available.
4 "Coal Resources of the World," pp. 360-371.
5 See J. W. Evans, "Coal Resources of the World," Vol. I, pp. 349-350; J. B. Scivenor, Report on the Rantan Panjang Coal Measures, 1911.

CHAPTER III

IRON AND STEEL IN FAR EASTERN COUNTRIES

STEEL forms the skeleton framework within the body of modern civilization. Without steel the whole range of power-generating and power-using industries would be virtually impossible. Modern building requires enormous quantities of it, speedy and abundant transportation are alike dependent upon it; communication, whether by telegraph, telephone, and radio, is similarly conditioned. The tools of industry and the implements of war, the thousand and one essentials and conveniences of daily life are all made in whole or in part of steel. The ease and certainty with which under ordinary conditions of trade it is available to any country have led us to forget how essential it is, but in times of war or general trade disturbance a shortage of this material promptly drives home the fact that steel is necessary to modern industry. In the world as it now is, no nation can be strong in time of peace or safe in time of war without an adequate supply of this basic material.

Steel is made from iron, being an alloy of that metal with carbon and usually various other elements in minor amounts. Iron is one of the commonest and most widespread metals of the earth. It is found, however, almost exclusively in compounds from which it must be reduced by metallurgical processes before being adapted to use. Not all the iron found in the crust of the earth is adapted to known processes, or if so adapted, occurs in such richness or in deposits of such size as permits treatment at any cost within reason. The black sand often strikingly in evidence on a seashore contains iron; but rarely, if ever, is it a possible source of supply for industry. In a specific case, careful sampling developed that it would be necessary to mine 70 to 200 tons of the sand to produce one ton of black sand concentrate

and that the latter would then contain such a large amount of titanium and other deleterious impurities that to make iron from it was only feasible on a laboratory scale and without regard to cost. In competition with deposits from which ore containing 60 percent or more of iron capable of being mined in train-loads by steam-shovel and fed raw into well-situated blast furnaces, it must be clear that the particular black sand deposit sampled had no value. It is cited to indicate that the mere widespread presence of iron does not mean that an iron and steel industry may be built up.

To make steel it is first necessary to reduce the ore to pig iron or molten iron. This is usually done in a blast furnace into which is fed iron ore, coke or charcoal, limestone and a stream of air under pressure to furnish the oxygen necessary for combustion. The amounts of these various constituents needed depend upon their composition, but in a modern well-built and well-operated blast furnace it might well require, in order to make one ton of pig iron, two tons of iron ore, one ton or a little less of coke, a half ton of limestone, and four to five tons of air. To make the coke itself would require a ton and a half to a ton and two-thirds of a special kind of coal known as coking coal. Since coal is also burned to furnish power and heat for other incidental purposes it may be taken that roughly four tons of coal and two tons of iron ore will be needed to produce one ton of steel.

To assemble all these materials, and to carry away the finished product and the waste requires furthermore a well developed system of transport and a close-knit organization. Since modern blast furnaces are built to produce 300 to 500 tons of pig iron per day and often greatly exceed these amounts, and since it is rarely advisable to build and operate a single blast furnace but instead furnaces are erected in groups, it is also evident that only deposits capable of yielding suitable ore in millions of tons, can be taken into account under modern conditions. It may well require 10,000,000 tons or more of ore to supply one furnace for a period sufficient to amortize the cost of plant and make the business profitable. Smaller furnaces than those mentioned are used,

it is true, and not all furnaces are driven at the high speed common in the United States, but any diminishing of size or slackening in the rate of output is promptly reflected in cost and handicaps the producer in competition. If steel is required in quantity and at competitive prices, there is no known way to produce the pig iron from which it is made except in large blast furnaces.

At various times and in various places, it has been proposed to manufacture steel direct from ore, usually by making a sponge iron and remelting it in an electric furnace. A considerable amount of experimental work along these lines has been conducted and a limited amount of actual production has been accomplished. The method involves many difficulties and the process requires close supervision. At present, a plant designed along these lines is being built in the Netherlands East Indies to use ore found in the Celebes, later to be discussed. The process is one adapted to small-scale plants, or rather it has not yet been worked out so as to permit quantity production. The plant cost is high and except where costs can in large measure be disregarded or where electricity is available at costs below those possible under any but the most exceptional circumstances, the process is not applicable. A modern blast furnace and steel plant, if at all favorably situated, can produce steel so much faster and so much cheaper that its output can stand a heavy freight charge and still undersell that from any direct-process plant built along lines now known or anticipated. It seems unlikely that improvements in technology will make it possible ever again to satisfy the world's requirements from the small scattered deposits of iron that up to the last half century were individually sufficient to support furnaces.

In the manufacture of steel from iron, manganese is used as a deoxidizer. It is necessary to have approximately fourteen pounds of manganese for each ton of steel made, though this does not enter into its final composition. In modern works aluminum is also used as a scavenger, and in making alloy steels for special purposes there is added to the final liquid bath variable amounts of tungsten, vanadium, molybdenum, or other metals according to the purpose for

which the steel is to be used and the particular qualities which it is desired it shall have. These ferro-alloy minerals, particularly the manganese, are just as essential as are the iron ore, limestone and coke that are put in the blast furnace but the amounts used are much smaller. It will simplify discussion to say at once that none of the Far Eastern countries seem likely to find their steel-making capacity limited by deficiencies of any of these. Manganese occurs in China,[1] the Philippines,[2] Japan[3] and elsewhere and, while there is not present evidence of the occurrence in any of them of large deposits of high-grade manganese ore such as are found in India, Russia, Brazil, and on the West Coast of Africa, it is not impossible that they may be found. Manganese is one of the minerals for which the ancients had no use. The great deposits of the world represent residual concentrations resulting from surface decay of rocks. Conditions for its accumulation have been favorable in China and elsewhere and it is known to be present in important quantity. It is possible that an exportable surplus of real importance in world economics may be present though this is not known to be true. It is sufficient to note here that no reason exists to anticipate, for the Far East, a shortage in high-grade manganese such as has at various times been a serious problem for American steel-makers, though this confidence in the sufficiency of the local supply rests quite as much on the improbability of a major steel industry being built up there, as on any evidence of the occurrence of manganese in quantity.

The occurrence of tungsten and other ferro-alloy minerals

1 C. Y. Wang, "The Mineral Resources of China," Tientsin. On page 33 will be found notes on manganese deposits in Hunan, Kwangtung and Kiangsu. V. K. Ting, "Manganese Deposits at Hsi Hu Tsun, Chang Ping Hsien, Chihli." Bull. Geol. Surv. China, No. 4, Oct., 1922. W. H. Wong, China Year Book, 1925, cites localities and estimates current production at 50,000 tons per year.

2 Warren D Smith, "Geology and Mineral Resources of the Philippine Islands," Manila, 1924. On p. 464 he notes the occurrence of manganese, but states that no industry has as yet been developed. Engineers of the New York Orient Mines Company found deposits of possible commercial importance.

3 In "Mining in Japan," prepared for distribution at the Sesqui-Centennial at Philadelphia in 1926 by the Japanese Mine Owners' Assoc., the following summary of the situation was made: "Manganese ore deposits are widely distributed in Japan, but due to the small size of the deposits the yearly output is comparatively small. Therefore, the ore is being imported to meet the home demand. The manganese ore in Japan is a mixture of psilomelane and pyrolusite. The deposits are found in the Paleozoic in the form of lenses and in the Tertiary in the irregular shapes. In former times manganese ore was exported to foreign countries, but this situation has recently been changed, due to the rapid development of the iron works and the chemical industry at home, which has caused an increased demand for the manganese. Japan is now importing a large amount of manganese ore every year."

used to impart special qualities to steel will be discussed in another chapter.

The principal iron and steel industry in the Far East is in Japan, with a less important one in China. Outside these countries there is nothing of any more than extremely local importance east of India and north of Australia. Both of these countries are outside the scope of the present discussion. The actual situation as regards production in the various countries is shown in the following table:

PRODUCTION OF PIG IRON IN THE FAR EAST[1]

(In Metric Tons)

	Japan	*China*[2]	*Philippine Islands*
1919	690,000	276,000	..[3]
1920	613,000	257,000	83
1921	673,000	226,000	..[3]
1922	642,000	163,000	..[3]
1923	710,000	......[3]	..[3]
1924	698,000	......[3]	..[3]

The countries that have been considered as potential producers are China, Japan, the Philippine Islands and Netherlands East Indies. There is general agreement that in the maritime provinces of Siberia, in Siam, Indo-China, and the Malay States, no iron or steel industry of more than minor and local importance is reasonably to be expected. Iron ore is widely distributed in the Far East as elsewhere, but deposits of such grade and size, and in such situations as regards fuel, flux, transportation and markets as to be economically important, are rare.

Since China is the largest of the countries and the one within whose borders the largest bodies of ore and coal occur, it may be appropriately studied first. Iron mining and smelting have been conducted in China for 2,500 years and the Shansi iron industry is doubtless the oldest still in operation in the world. Iron is widely distributed and the presence of small native furnaces in various parts of the country has led to the general belief that the iron ore re-

1 Source: Japan; "Mining in Japan," p. 31, The Association of Mine Owners, 1926. China; Tegengren, p. 399. Philippine Islands; "Geology and Mineral Resources of the Philippine Islands," p. 446, Manila, 1924.

2 Native iron not included. The Chinese Ministry of Agriculture and Commerce estimates that the production of native iron in 1916 was 170 thousand tons. Tegengren, p. 314.

3 Figures not available.

FIG. 8. *Map showing location of principal coal, iron and copper deposits in the Far East.*

sources of the country are enormous. To this the writings of Baron F. von Richthofen [1] contributed greatly. That eminent geologist traveled widely throughout the country a half century ago and, in Shansi especially, seeing small native furnaces everywhere and coal abundant, jumped to the

[1] China. Ergebnisse eigener Reisen und darauf gegrundeten Studien. Berlin, 1877. Letters 1870-1872 to the Shanghai Chamber of Commerce. Sec. Ed., Shanghai, 1903.

conclusion that the country could furnish materials for a great iron and steel industry. His statement to that effect has been widely quoted. Largely as a result of expectations based on his writings, the Pekin Syndicate was formed to work the coal and iron deposits of the province. W. H. Shockley, a well informed American engineer, studied the province for that syndicate in 1898 and in October, 1903, presented to the American Institute of Mining and Metallurgical Engineers a paper describing the mines.[1] He found coal, both anthracite and bituminous, to be abundant and estimated the output of the iron furnaces to total 50,000 tons per year, coming from furnaces having a capacity of about one-third of a ton per day. Of the deposits he said:[2]

> "The iron ores are mainly limonites and hematites, occurring in Carboniferous shales and sandstones, as nodules, usually varying from a few pounds to a few hundred pounds in weight, though masses of several tons are said to have been found. Sometimes there are several layers of these nodules, sometimes there is only a single stratum. Iron ore occurs also in beds from a few inches to a foot or so thick, and in flat veins with a maximum thickness, at present, of three feet, though tradition says there have been beds of a thickness of twenty feet found in the past. The native methods extract from 25 to 35 per cent. of iron from these ores."

This description of the occurrence of the ores in the supposed richest part of China, supported by numerous detailed descriptions and measurements of individual deposits, is enough to make clear that the deposits which for centuries supported a native iron industry have no significance under modern conditions. This fact was pointed out by Thomas T. Read[3] when he prepared a summary of knowledge of China's iron ore resources for use of the International Geological Congress in making its survey of the world's reserve. Read had himself visited the Shansi mines

1 "Notes on the Coal and Iron Fields of Southeastern Shansi, China." Trans. A. I. M. E., Vol. XXXIV, pp. 841-871, 1904.
2 Op. cit., p. 843.
3 "The Iron Ore Resources of the Chinese Empire." "The Iron Ore Resources of the World." Vol. II, pp. 916-924, Stockholm, 1910.

in the winter of 1910, and regarding the deposits he wrote as follows:[1]

> "Usually they are masses of no great size, commonly in or near a disturbed zone in the strata, or else in beds or flat veins, from a few inches to not more than three feet thick, of limited extent. It follows, therefore, that no sufficient supply of uniform enough quality can be obtained from the Shansi deposits, so far as yet explored, to form the basis of blast-furnace work on a large scale."

In the closing years of the Manchu dynasty's rule over China, there was great interest in the mineral resources of the country and when Yuan Shih-kai became President, far-seeing plans were made for the study of the mineral and other resources preparatory to their development along modern lines. A geological survey was organized under the direction of V. K. Ting, who had received both a Chinese and a foreign education and had recently graduated at the University of Glasgow in Scotland. With him was associated W. H. Wong, who received his degree at the University of Louvain. At the same time, J. G. Andersson, the well-known Director of the Geological Survey of Sweden, was called to China to serve as Mining Advisor to the President. He associated with himself E. T. Nyström and F. R. Tegengren, both experienced mining geologists. Messrs. Ting and Wong, recognizing the size and responsibility of the task committed to them, and the need of an adequately trained staff, spent the first two years in the conduct of a Geological Institute at the University in Peking, training some thirty selected students in the principles of modern geology and methods of making surveys. From among the graduates of this course eighteen were selected, who became the working staff of the new Survey. A number of these have since supplemented their home training by graduate studies abroad.

Ting and Wong proved to be not only good geologists and good organizers but inspiring leaders, and the young men who have worked with and under them have given ex-

1 T. T. Read, "The Mineral Production and Resources of China," Trans. A. I. M. E., XLIII, New York, 1913, p. 26.

cellent account of themselves. With inadequate appropriations, poor and uncertain pay, amid civil war, and faced by every discouragement, this little force has done a surprising amount of scientific work fully comparable in quality to that turned out by similar organizations in other lands under happier circumstances. The familiarity of the staff with both Chinese and foreign literature has given it a special advantage and makes its reports peculiarly valuable. Too many foreign experts misunderstand or misinterpret things Chinese or fail to tap resources of local information; while on the other hand Chinese writers who, unlike this group, have no foreign experience, are necessarily handicapped by lack of appreciation of the underlying economics and technology on which development in the industrialized countries rests.

J. G. Andersson was a specialist on iron ores. He had, indeed, served as editor of the monumental report on the iron ore resources of the world compiled and published by the International Geological Congress, when it met in Stockholm in 1910,[1] which is the standard authority on the subject of iron ore reserves. T. T. Read and Director K. Inouyè of the Imperial Geological Survey of Japan, who had furnished the Congress reports on Chinese iron ores, had worked with but the scantiest and most uncertain data. Accordingly, Andersson came to China familiar at once with the important place of iron in the modern world and the almost complete lack of information, tested by modern standards, regarding Chinese iron ores.

He found the President keenly alive to the importance of the matter and a systematic study of the ores of the country was at once projected. In the succeeding years it was carried out with the complete coöperation of all concerned as rapidly as proved possible. The results of this survey form the subject matter of a memoir of the Geological Survey of China, consisting of two volumes and an atlas[2] printed in Chinese and English and constituting not only the most comprehensive summary of knowledge of the

1 "Iron Ore Resources of the World."
2 Tegengren, F. R., "The Iron Ores and Iron Industry of China, Including a Summary of the Iron Situation of the Circum-Pacific Region," with atlas. Mem. Geol. Surv. China, Ser. A, No. 2, English text 457 pp. Peking, 1921-24.

situation of the iron ore situation in China but a scarcely less valuable comparison of it with conditions in other countries bordering the Pacific.

The report is much too long to be summarized here. For

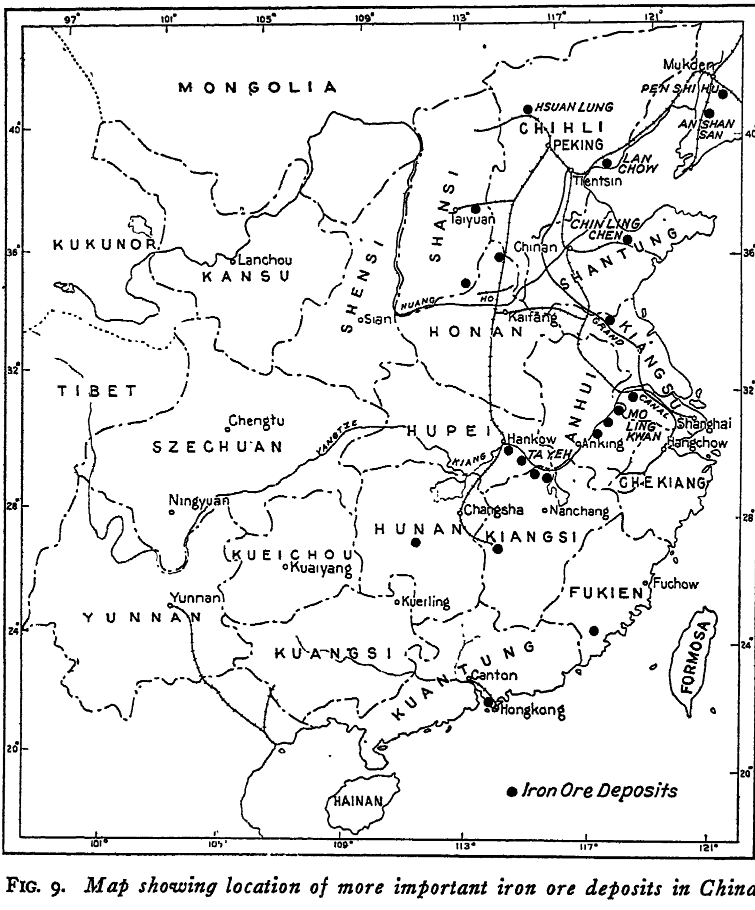

FIG. 9. *Map showing location of more important iron ore deposits in China.*

details as to individual deposits and enterprises or even descriptions of classes of ores, reference must be made to the original text. As a practical matter the iron ore likely to be of value in building up a modern industry were found to be of three types which Tegengren describes [1] substantially as follows:

1 Op. cit., Pt. 1, p. 7, *et seq.*

(1) "Archean ores, probably of sedimentary origin, forming part of a basal complex of crystalline schists with granitic intrusions, which is exposed in larger and smaller areas over a vast territory in northeastern Chihli and Southern Manchuria. The ores, distinctly quartz-banded crystalline hematite and magnetite, occur as extensive layers occupying a definite stratigraphic horizon between mica schists, and quartzite. As a rule the ore is poor, and extremely siliceous, containing some 30 percent of iron and above 50 percent of silica, but also beds of high grade, although somewhat sulphurous, ores met with at some places.

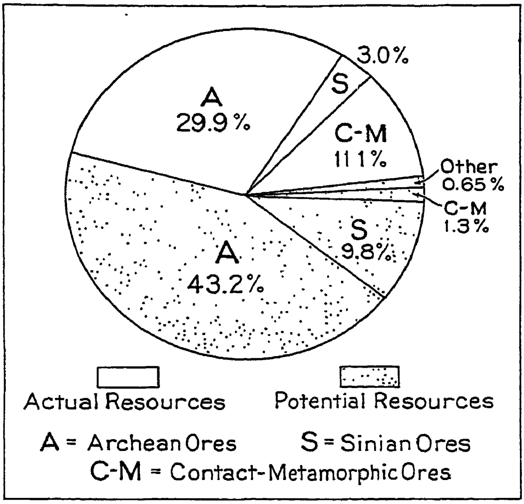

FIG. 10. *Diagram illustrating the percentage of iron ores of various types forming China's reserve.*

(2) "Pre-Cambrian bedded hematite ores (Hsuan-Lung type), with an oölitic or stromatolitic structure. These ores form well-defined beds, alternating with quartzitic sandstone and slate. Only one complex of occurrences, all of them forming part of one and the same original basin of deposition, is known to exist. These deposits, found in the Hsüan-Lung region in northwestern Chihli, together constitute one of the most important ore resources of China. The ore is high grade, with some 48-56 percent of iron as an average, and has a medium content of phosphorus (average 0.12 percent) and is practically free from sulphur and other objectionable constituents. They are the first known representatives of Pre-Cambrian oölitic ores.

(3) "Hematite and magnetite ores in genetic connection with igneous intrusions of grano-dioritic rocks of Post-Carboniferous age. (Contact metamorphic tpye.) This group is by far the most important one, including several of the largest deposits known in China. The ore deposits, varying in size from minute

occurrences of merely scientific interest, to large bodies, containing millions of tons, appear at, or near, the contact between laccolithic masses of grano-diorite and pre-existing sedimentary rocks of both calcareous and siliceous composition. It seems justified to conclude that the ores were chiefly metasomatically deposited from aqueous solutions during a period following the consolidation of at least the marginal parts of the dioritic intrusions. The ores consist of hematite and magnetite, the former mineral as a rule predominating. The hematite is partly of a very finely granular or dense structure, but micaceous specularite is also not uncommon, especially in druses and cavities. The magnetite is mostly met with where the ore bodies come into immediate contact with the diorite, but also seems largely to occur in intimate intermixture with the hematite. Hydrated iron minerals, such as limonite, are encountered in the superficial portions of the deposits. As already stated, quartz makes up the bulk of the associated gangue matter; besides several of the deposits are also mixed up with garnet and epidote. In some cases idiomorphic feldspar is met with in considerable amount. Sulphide minerals such as pyrite, chalcopyrite, and bornite also frequently accompany the ore, occasionally in such a proportion that the commercial value of the ore is considerably lessened. At one place (Ta-Yeh), according to the experience gained hitherto, the amount of sulphides increases towards the depth.

"Occurrences of this type are widely distributed in Eastern and Central China and are encountered as far north as Manchuria and as far south as Canton. Deposits of economic value are found in Shantung and Honan, but the greatest number of orebodies, some of very considerable size, seems to belong to a belt along the Lower Yangtse valley in the provinces of Kiangsu, Anhui, Kiangsi and Hupei. The ores are somewhat inhomogeneous, but the bulk is high grade, ranging about 60 percent in iron, with an intermediate percentage of phosphorus and a varying, but as a rule not objectionable, content of sulphur. The ores of this type seem to be closely related to those of Korea and Japan, as well as the deposits along the Pacific Slope of the Americas."

Mr. Tegengren's[1] Summary of the ore reserves of China may be quoted in abstract in the pages following, and a

1 Op. cit., p. 287, *et seq.*

graphic representation of the relative importance of the reserves of the different types has been shown in Fig. 10.

The Archean Ores of Chihli and Fengtien: "The resources of the extensive Archean belt of low-grade hematite-magnetite ores are embodied in the following tabulation:

ARCHEAN IRON ORE RESERVES OF CHINA

	Tonnage of Ore	Tonnage of Metallic iron contained	Average Composition of Ore: Fe %	SiO2 %	P %	S %	No. of anal.
Chihli, Luan-Hsien Region	32,000,000	9,600,000	30.00	52.00	0.05	0.04	5
Fengtien, Miao-er-Kou Region	70,000,000	25,000,000	36.41	46.20	0.05	0.02	6
Fengtien, Kung-Ch'ang-Ling Region	268,000,000	90,000,000	33.84	51.31	0.07	0.16	5
Fengtien, An-Shan Region	400,000,000	144,000,000	36.00	46.00	0.03	0.02	..
Fengtien, Kuo-Ti-Shan	2,000,000	600,000	29.31	56.00	0.05	0.12	4
Total	772,000,000	269,200,000	34.9	48.1	.05	.07	

"Large though these tonnage figures may seem—they are by far the largest that any group of deposits in China can boast of—the economic exploitability of the deposits depends entirely on the successful solution of the concentration problem. Since the amount of high grade ore occurring in minor bodies within the mass of low-grade ore is very limited—hardly exceeding 1 percent of the tonnage of low-grade ore—and since this minor portion is, moreover, not recoverable without mining the whole iron formation, it is evident that any scheme of exploitation must be based primarily on the utilization of the bulk of low grade ore.

"There may be a possibility that new deposits of this kind will be revealed by a detailed survey of the detached Archean areas of Northern Chihli and Southern Manchuria. However, considering the fact that these areas are rather limited in extent, and that the deposits, as a rule projecting as hills, are comparatively easily traced, there seems to be little likelihood that any large orebodies could hitherto have escaped attention.

Ores of the Hsüan-Lung Region: "This ore region, situated in the northwestern part of Chihli province, is among the most important in China. The tonnage estimates and assays already given for this group of deposits have been condensed in the following tabulation:

SEDIMENTARY IRON ORE RESERVES OF CHINA

	Tonnage of Ore	Tonnage of Metallic iron contained	Average Composition of Ore Fe %	SiO2 %	P %	S %	No. of anal.
Known Resources.							
Hsin-Yao	17,836,000	9,470,000	53.10	15.90	0.12	0.03	31
P'ang-Chia-Pu	14,863,000	8,650,000	58.17	13.81	0.14	0.03	22
Yen-T'ung-Shan	12,946,000	6,190,000	47.80	25.00	0.15	0.02	27
Total	45,645,000	24,310,000	53.3	17.8	0.13	0.03	
Imperfectly Known Resources.							
San-Ch'a-K'ou	3,000,000	1,580,000	52.66	16.28	0.08	trace	2
P'ang-Chia-Pu	43,000,000	24,550,000	57.10	14.18	0.17	0.031	6
Total	46,000,000	26,130,000	56.8	14.3	0.16		
Grand Total	91,645,000	50,440,000	55.1	16.1	0.15	0.03	

"In classifying the resources as above into known and imperfectly known ones, no regard has been paid to the geographical position of the respective ore fields and to the transportation problem. Naturally, in such a mountainous country as this, the latter enters very largely into the question of exploitability. The distances of the various ore fields from Hsüan-Hua-Hsien city, on the Peking-Kalgan railway are as follows: Hsin-Yao—70 kilometres; P'ang-Chia-Pu—40 kilometres; Yen-T'ung-Shan—10 kilometres.

"Yen-T'ung-Shan has already been opened up and connected with the Peking-Kalgan railway by means of a branch line, and may hence be included among the actually available resources. P'ang-Chia-Pu, although lying at an elevation of about 420 metres above Hsüan-Hua, may also be easily reached by a branch line, since the grade is even as far as about 5 kilometres from the deposit. But in order to tap the Hsin-Yao (and San-Ch'a-K'ou) resources the pretty steep pass at Kuan-Ti—which rises to an elevation of about 140 metres above the adjoining level ground—has to be crossed and, since the country beyond that pass is again at a lower level, the loaded cars from Hsin-Yao would have to ascend this pass. Owing to these difficulties of transportation and the considerable distance, it seems advisable not to include the Hsin-Yao deposits among the resources at present available for profitable mining. Hence only the resources of Yen-T'ung-Shan and P'ang-Chia-Pu should be reckoned with as mineable under present conditions.

"As regards the possibility of future discoveries of additional deposits, it may be intimated that the observations so far made

tend to prove that the stratigraphic horizon in which the ore has been deposited does not contain any workable ore outside the Hsüan-Lung region proper. On the other hand, it may be pointed out that, so far, the detailed geological survey has not been extended to the remoter parts of this region and that it is by no means improbable that isolated ore fields may be found southeast of the main outcrop-zone.

Contact-Metamorphic Ores: "From an economic point of view this group of deposits is at present by far the most important one. This prominence is due not merely to the comparatively high grade and purity of the ores but also equally to the geographical position of the majority of the deposits in the vicinity of the great commercial artery of central China, the Yangtse river.

"The resources of ore contained in this group of deposits are tabulated below:

ACTUAL CONTACT IRON ORE RESERVES OF CHINA

	Tonnage of Ore Resources	Tonnage of Metallic Iron Contained	Fe %	*Average Composition of Ore* Mn %	SiO2 %	P %	S %	Number of Analyses
Chihli								
Chi-Kuan-Shan	700,000	280,000	40.0					
Shantung								
Chin-Ling-Chen ...	13,700,000	7,600,000	55.3	(0.21)	10.5	0.04	0.65	15
Honan								
Hung-Shan	740,000	450,000	60.7	Not det	9.4	0.02	0.08	
Hupei								
Ta-Yeh, Hanyehping Mines	10,500,000	6,250,000	59.5	0.23	9.2	0.10	0.32	
Ta-Yeh, Hsiang-Pi-Shan	8,800,000	5,070,000	57.6	(0.13)	9.4	0.06	0.06	15
Ling-Hsiang	6,340,000	3,840,000	60.6	Not det	10.3	0.03	trace	7
O-Ch'eng	10,000,000	5,450,000	54.5	Not det	20.7	0.02	0.02	8
Anhui								
T'ung-Kuan-Shan..	2,500,000	1,470,000	58.6	Not det	9.4	0.08	0.13	6
Yeh-Shan	?	?	51.4	Not det	13.3	0.04	trace	3
T'ao-Ch'ung	3,750,000	2,300,000	61.4	0.17	11.2	0.02	0.01	3
T'ai-P'ing-Nan-Shan	2,000,000	1,250,000	62.3	Not det	5.8	0.21	0.16	10
T'ai-P'ing-Lo-Pu Shan	150,000	90,000	57.3	Not det	11.0	0.42	0.07	1
T'ai-P'ing-Wa-Shan	1,750,000	1,100,000	58.0	Not det	9.0	0.67	0.11	14
T'ai-P'ing-Tung-Shan	200,000	112,000	56.2	Not det				
T'ai-P'ing-Huang-Mei-Shan	200,000	132,000	66.0	Not det	3.4	Not det	Not det	1
T'ai-P'ing-Chung-Shan	3,000,000	1,600,000	53.1	(.24)	15.4	0.44	0.05	17
T'ai-P'ing-Ku-Shan	1,700,000	890,000	52.5	(0.15)	21.1	0.22	0.07	3
T'ai-P'ing-T'iao-Yü-Shan	125,000	60,000	49.2	Not det	24.3	0.08	0.07	
Kiangsu								
Li-Kuo-Yi	3,000,000?	1,500,000?	50.0					
Feng-Huang-Shan	4,300,000	2,150,000	49.9	Not det	18.8	0.29	0.05	31
Chekiang								
Ch'ing-Niu-Shan ..	200,000	82,000	41.0	Not det	29.5	0.09	trace	2
Fukien								
Su-Luan	2,000,000	1,000,000	51.2	Not det	9.64	0.04	0.35	
Kiangsi								
Cheng-Men-Shan ..	6,300,000	2,640,000	42.0	Not det	27.1	0.19	0.17	8
T'ung-Ling-Shan ..	580,000	300,000	52.5	1.96	9.2	0.15	0.06	3
Total	82,535,000	45,616,000	55.3					

"The above table embodies practically all known deposits of any actual or prospective importance. Several of them are, however, hardly workable under present conditions, partly owing to their geographical position and partly owing to the inferior grade of the ore. If we try to exclude all resources that from this point of view may be considered at present unavailable we find, however, that these make up only a minor portion of the total, as may be gathered from the following tabulation including only the actually available resources.

ACTUAL CONTACT IRON ORE RESERVES OF CHINA

	Tonnage of Ore	*Tonnage of Metallic Iron Contained*
Chin-Ling-Chen	13,700,000	7,600,000
Ta-Yeh	19,300,000	11,319,000
Ling-Hsiang	6,340,000	3,840,000
O-Ch'eng	10,000,000	5,450,000
T'ung-Kuan-Shan	2,500,000	1,470,000
T'ao-Ch'ung	3,750,000	2,300,000
T'ai-P'ing, Northern	4,300,000	2,684,000
T'ai-P'ing, Southern	4,825,000	2,550,000
Feng-Huang-Shan	2,000,000	1,000,000
Cheng-Men-Shan	6,300,000	2,640,000
Total	73,015,000	40,853,000

"The group of iron ores here under consideration is the main one that has so far been the object of mining operations on a modern scale.

"As regards the prospect of future discoveries, this seems to be as follows: From theoretical considerations it may be regarded as highly probable that, since the orebodies occur along the contact-zones between various sedimentary rocks and igneous masses intruded into them, and since a systematic survey of such contact-zones where new deposits are likely to be found has not yet been undertaken, such systematic surveys may lead to the discovery of orebodies which have hitherto escaped attention. On the other hand, it must be remembered that the majority of these deposits, owing to the physical character of the ore, are liable to form the crest of hills. They thus, as a rule, occupy a conspicuous topographical position, where they are not likely to have escaped even the nonscientific prospector's attention. Hence, it may be predicted that the undiscovered deposits, which undoubtedly exist, may be found chiefly in localities where the contact-zone has not yet been exposed by the sub-aerial denudation, that is to say, where the ore-bearing zone is hidden under a more or less extensive overburden of sedimentary rocks. Deposits in such a position would, how-

ever, have to be worked by underground mining and would thus be at a considerable disadvantage as compared with the deposits which crop out on the present land-surface.

Other Types of Deposits: "Notwithstanding their widespread distribution over considerable regions in northern and western China and the undoubtedly very large aggregate tonnage they contain, there is little likelihood that the nodular deposits of Paleozoic and Mesozoic strata will ever attain any commercial importance from a modern industrial point of view. The ores are of comparatively low grade, the individual ore-bodies are small and scattered and the accessible portions of the ore-bearing strata are limited. But as a supply for the local native iron smelters they will probably, as in the past, be utilized for several decades ahead. The metasomatic hematite beds in eastern Hunan and western Kiangsi are not likely to prove workable owing to the thinness of the ore beds. The river bed iron sand, washed by the natives in many parts of the country, is generally very poor and obtainable in very limited quantities. It has therefore no economic importance, beyond supplying the small local native smelters with their requirements. Among the deposits reviewed in the preceding pages, there are several on which the information available is too vague and indefinite to permit of any reliable classification. . . . On the whole, however, it seems not likely from the data at hand, that these deposits will prove of any more than quite local significance.

"An attempt may be made to condense in one single table the estimates given above for the different groups of deposits. At the same time a distinction may be attempted between actual and potential resources. Such a classification must necessarily be somewhat arbitrary.

SUMMARY OF IRON ORE RESOURCES OF CHINA

	Actual		*Potential*	
	Tonnage of Ore	*Tonnage of Metallic Iron Contained*	*Tonnage of Ore*	*Tonnage of Metallic Iron Contained*
Archean Ores	295,000,000	110,000,000	477,000,000	159,000,000
Sinian Ores, Hsüan-Lung Region	28,000,000	15,000,000	64,000,000	36,000,000
Contact-metamorphic Ores	73,000,000	41,000,000	9,600,000	4,800,000
Other Types	....	....	5,100,000 [1]	2,400,000
Total	396,000,000	166,000,000	555,700,000	202,200,000

[1] This figure does not include the nodular ores of Shansi, which, though the aggregate tonnage is very large, will very likely never be worked on a modern scale, and it is to be noted that the preceding tables included all ore, probable and actual, regardless of iron content.

"It is at once evident that 950 million tons of iron ore is by no means much for China and even if continued investigations would—what seems rather improbable—raise these known resources to the double amount, the general situation would not be essentially altered. One thing, therefore, is certain: China can no longer be regarded as a storehouse of inexhaustible future reserves of iron ore, to be drawn upon when the supplies of other countries are beginning to give out. On the contrary, her iron ore resources must be termed very modest, or even scant, when her potentialities of industrial development are taken into consideration, and the strictest economy would be indispensable to guard against future unpleasant contingencies. By way of illustration it may be pointed out that the total quantity of iron ore (both actual and potential) represented by the figures above would be consumed by the iron industry of the United States within less than nine years. And then it has to be noted that the bulk of these resources consists of the low grade Manchurian ores, the exploitability of which is still somewhat problematical, or which at any rate are far below the average standard."

As Mr. Tegengren notes, the largest amount of ore entering into these estimates is that of the "Archean" type, which is credited with a possible 772,000,000 tons containing just under 35 percent metallic iron. These estimates are based upon studies of a series of detached deposits forming a line from the Korean borders across the Manchurian province of Fengtien, passing presumably under the Liaotung gulf and reappearing at Lung-hsien in Chihli.[1] The total distance is about 350 miles and despite the apparent narrowness of the zone it is, as Tegengren remarks,[2] comparable in extent with the great iron ore ranges of America and Europe. Unfortunately, it is by no means comparable as to grade and very little of the material would be classified as ore in calculating reserves elsewhere. Along the range there are at a few points bodies of ore containing 60 percent or more metallic iron and capable of being smelted direct in blast furnaces. Tegengren believes these to be the result of later local concentration due to heated waters from nearby intrusives, and estimates that such ores are extremely limited in amount and represent less than 1 percent of the total.

1 The principal localities are indicated in Fig. 7.
2 Op. cit., p. 97.

Specifically, he estimates[1] the total high-grade ore in the four Manchurian districts as amounting to but 6,300,000 out of the total of 740,000,000 credited above.

As an example of these orebodies, the description of that at Miao-er-kou may be quoted from the general article on the Pen-hsi-hu district by C. F. Wang, a Columbia graduate connected with the Sino-Japanese Company operating coal and iron mines and blast furnaces at that point.[2]

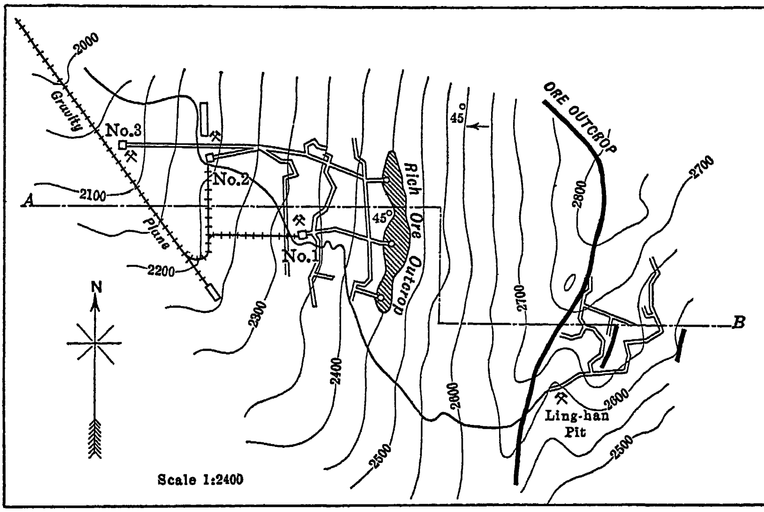

FIG. 11. *Plan of Miao-er-kou mine; after C. F. Wang.*

"The great magnetite belt in Fengtien Province is extensive in area and the deposits are of large size. Near Liao-yang, at An-shan-chang, poor ores—from 30 to 50 percent iron—occur mostly in the form of magnetite in layers with quartz. Near Yao-chien-hu-tun, at Wai-tou-shan, the ore contains 40 to 50 percent magnetite, dipping 45° west and about 100 feet (30 metres) thick, lies between quartz-porphyry and gneiss. At Miao-er-kou, the ore zone is 300 to 600 feet thick, including two rich veins, 50 and 33 feet thick respectively, and 66 to 70 percent iron. The ore lies between walls of talc-schist. Above the talc-schist is gneiss and quartzite. The tunnel intersects pure white talc-schist, chlorite schist, poor ore, and

1 Op. cit., p. 121.
2 Wang, C. F., "Coal and Iron Deposits of the Pen-Hsi-Hu District, Manchuria." Trans. A. I. M. E., LIX, p. 413, 1918.

finally the rich ore. The rich ore is so far known to be about 480 feet long and 50 feet wide, narrower at the middle and ends. At present there are three levels 120 feet apart and a fourth level is being driven. A cross-cut from the first level cuts the eastern rich vein, the Lingnan-k'eng, or Ling-nan pit. Two other rich veins of 15 to 25 feet exist further east of the Ling-nan pit. This ore belt at Miao-er-kou can be traced north for about a mile from where the ore bin is located, at the point where the gravity plane connects with the light railroad. There must be two faults or more; one cutting the talc-schist which here forms the eastern hill with the quartzite appearing in the opposite hill a few feet away. No gneiss can be seen except to the east, where the quartzite lies above the gneiss; a little further east the gneiss predominates. Here along this valley, there

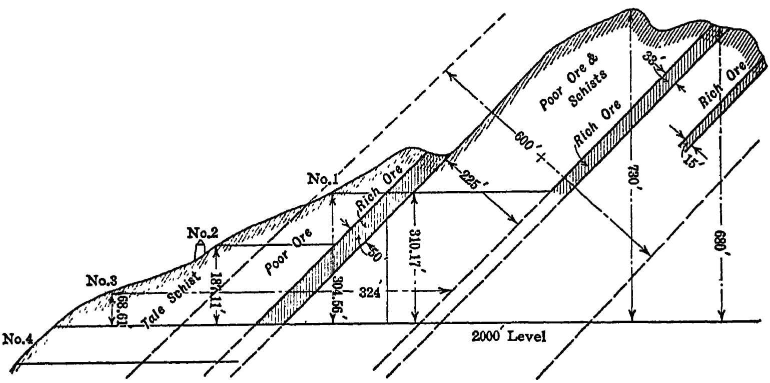

FIG. 12. *Cross section of Miao-er-kou orebody; after C. F. Wang.*

must be a second fault. The ore disappears, reappearing in the southeastern hills at Hei-shan-pei. Most of this ore is low grade, it can be traced for over 4 miles, roughly speaking. On a conservative estimate, the orebody at Miao-er-kou, with about 500 feet now developed, must contain over 100,000,000 tons, of which about 2,000,000 tons contains 60 to 70 percent iron.

"In the hills to the west of Ch'ao-ho, at Ti-hsiung-shan another magnetite body occurs. The magnetite there, dipping about 45° to 50° west, lies between rhyolite-porphyry and talc-schist, which is of widespread occurrence in this part of the country. The orebody is about 30 feet wide and extends a few hundred feet, dipping about 65° southwestward. The eastern side has better ore, but it is lower in level. This ore has been worked for over 80 years by the natives and about 250 tons of

the ore per year is smelted at Sai-ma-chi for manufacturing agricultural implements and home utensils, in a small cupola furnace 6 feet high and 2 feet in diameter. No limestone is used, the coke is 2:1 of iron ore by volume. . . . Ten miles further westward, at Tung-yuan-pu, 30 miles southeast of Nan-fen, or about 40 miles southeast of the Miao-er-kou deposit, the magnetite body is again found. It is darker in color between gneisses. It is about 30 feet wide, dipping 30° west and about half a mile long. A conservative estimate of the orebody here is 1,000,000 tons of ore of about 60 per cent. iron. I have found poor ore also at Hsiao-hei-shan, two miles east of Tung-yuan-pu, and at Fan-chai-tai. All these are associated with gneiss and talc-schist. There are probably other places of which I have not been informed, or have not yet found. In a general way, this great magnetite belt probably contains over 500,000,000 tons of ore, including rich and poor, associated with talc-schist and gneiss."

It will be noted that Mr. Wang credits to the magnetite belt "including rich and poor," a possible 500,000,000 tons of ore and to Miao-er-kou, 100,000,000 tons of which 2,000,000 contains 60 to 70 percent of iron and accordingly, is all that may properly be considered as ore now. Mr. Tegengren's estimates made later, give 740,000,000 as the gross probable tonnage for the Manchurian belt of iron-bearing rocks; 70,000,000 tons for Miao-er-kou alone; and 2,000,000 tons for the high grade.[1] The estimates of gross tonnage are in all cases approximations only.

In considering the real value of the Archean ores it is clear that their grade is all important. The analyses quoted by Tegengren[2] show that he as well as Wang classified as high-grade ores those ranging from 60 to 70 percent in iron. The low-grade ore ranged from 34.58 to 37.83 percent in iron with silica of 45.74 to 49.84. Such material is not suitable for the furnace but requires preliminary treatment. The fact that much the larger part of the material found in the iron-bearing belt is of this grade and character was not at first recognized, and both the Pen-Hsi-Hu and the Anshan companies have found themselves obliged to revise their plans to meet this situ-

1 Op. cit., p. 102; p. 121.
2 Op. cit., p. 105.

ation. To work such ores will require fine crushing to permit separation of the iron from the silica and after that either wet or magnetic concentration. Of these the latter seems likely to be required for most of the ore, and it will require generally a preliminary roasting. Finally, the iron concentrate must be sintered or briquetted before it can be fed into the furnace. Methods for accomplishing all this are known and in part have been worked out in their application to Manchurian ores. They all, however, add to the cost of the furnace burden and constitute a handicap for enterprises dependent upon these deposits. In the Lake Superior region of the United States there are millions of tons of similar material not counted as ore and large sums of money and much technical ability have been devoted to making from them an acceptable furnace material. While the technical results of the work were all that could be desired it has so far proved impossible, despite the expenditure of money necessary to give the enterprise the full benefit of large scale operations, to produce a sinter that can compete regularly in the general market with the raw ore still abundant in that region. In New York, and at various places in the world, magnetically concentrated iron ores are used but resort is only made to them when special properties are desired or special conditions of market or manufacture permit.

In time, doubtless, beneficiated iron ores will be commonly used but not so long as raw ores of suitable grade and character are available. For the present, and for a period that it is not now feasible to define, the iron-bearing rocks of the Archean in Fengtien and Chihli can only properly be considered ores to the extent that they contain ore of the "rich" class. So far as present knowledge goes, this reduces them to a minor position. It is possible, indeed probable, that closer geological studies and more careful prospecting with diamond drills or otherwise will reveal the presence of additional bodies of "rich" ore. The area is large, the indications favorable and the need of the local furnaces, particularly that at Anshan, will in time force this exploration. In 1922, a commission of American mining engineers and geologists consisting of Messrs. W. R. Ap-

pleby, W. J. Mead, W. H. Crago and Frank Hutchinson studied the iron ore problems of the Anshan plant for the owning corporation, the South Manchuria Railway. While no report has been published it is generally understood that they pointed out areas for prospecting with the hope that sufficient high-grade ore might be found to supply the works, but in the records as now known there is nothing to warrant belief that the region offers opportunity for development of an iron and steel industry of world importance.[1]

Probably the most important single iron ore region in China is the Hsüan Lung in the rough mountainous belt that separates the Chihli plain from the Mongolian plateau. Here, 135 to 170 miles northwest of Peking, is a remarkable series of deposits of which the importance was not recognized until 1914. It was Bailey Willis, apparently, who first, recognizing the geological similarity of the formations of this horizon to those in the Lake Superior region, suggested that search for iron ore might well result favorably.[2] No attention seems to have been paid to this hint, if indeed it was known in China, and attention was first attracted to the deposits by sale of some of the ore for making red paint in 1912.[3] The deposit attracted the attention of Okura & Co. but was condemned by Japanese experts evidently unfamiliar with this type of ore. When in 1914, it was called to the attention of Andersson he at once appreciated its possible importance and under his advice the Geological Survey made the topographic and geological surveys and did the sampling that demonstrated the value of the deposits.

The iron is found in the form of a series of oölitic and stromatolitic sedimentary beds between slates and quartzites. The beds are of workable thickness, well situated for mining, and, as already indicated, the total tonnage is of the order of 90,000,000, with an average composition of:

	Percent
Fe	55.10
SiO_2	16.10
P	0.15
S	0.03

1 The geology of these particular deposits has been mapped in detail by H. Murakami and his report has been published by the South Manchuria Railway.
2 "Mineral Resources of China." Economic Geology, Vol. III, p. 29, 1908.
3 For history and detailed descriptions, see Tegengren, op. cit., pp. 24-87.

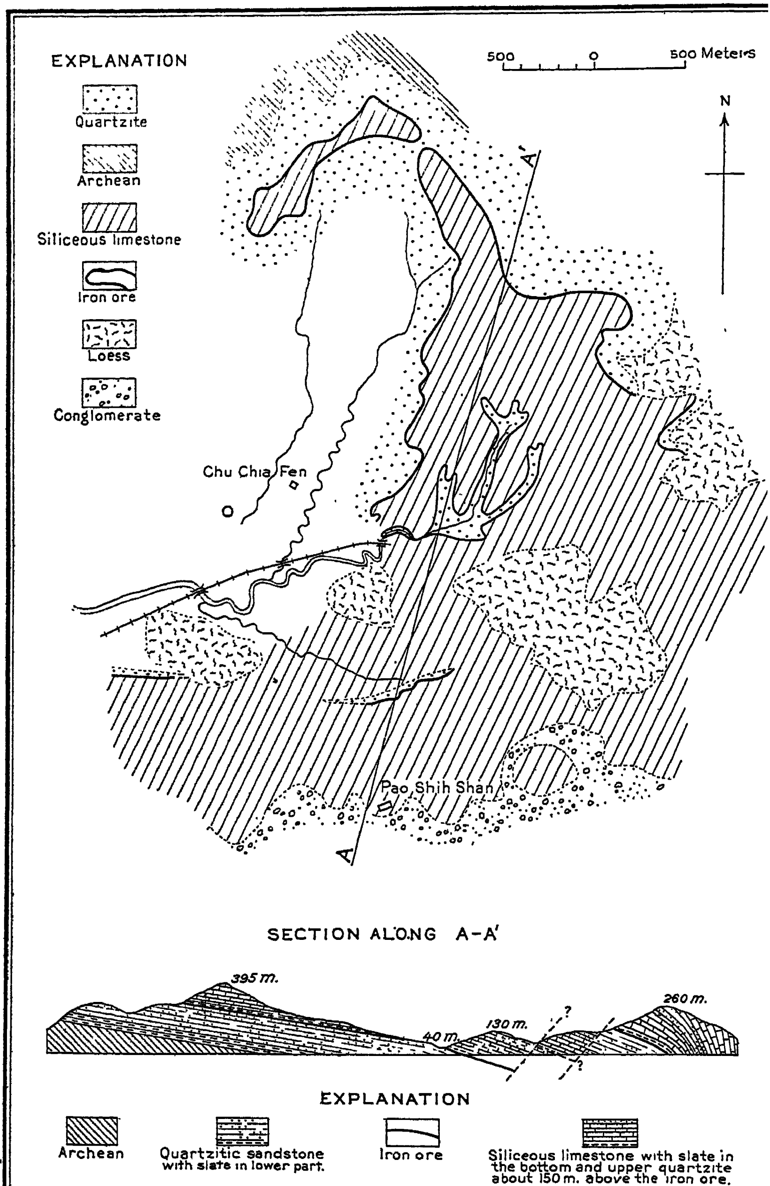

FIG. 13. *Map and cross section of Yen Tung orebody from surveys by J. G. Andersson as shown on plate 8 of Tegengren's atlas. The figure illustrates how the ore occurs as a bed between the quartzite and limestone.*

The ores are similar in occurrence and in appearance to the "Clinton" ores which form the basis of the iron industry of Alabama; and owing to the mode of their occurrence and the care with which the surveys were made, confidence in the tonnage estimates is fully warranted despite the fact that they were preliminary only. Unfortunately, as contrasted with Clinton ores, the impurity is mainly silica in place of lime. This makes the ores more expensive to smelt because lime must be added and more fuel needs to be used. None the less they form a suitable basis for an iron industry, the difficulties involved being those connected with the cost of assembling scattered raw materials and marketing the output.

The third important class of iron ores in China, and the one which has so far furnished most of the iron, is the contact-metamorphic ores. An estimate of the amount available at various points has already been given, and the actual reserves are placed by Tegengren at 73,015,000 tons containing 40,853,000 tons of iron. It is notoriously difficult to make accurate advance estimates of tonnage in contact-metamorphic deposits. The bodies are extremely irregular and continuity in any direction can not be assumed in advance of actual exposure. This accounts for the fact that the uniform result of closer studies of the individual deposits in this class has been to decrease the amount of ore apparently present. Since sharp controversy, at times threatening international complications, has raged around several of these occurrences, a few detailed examples may be cited.

Chin-ling-chen is a station on the Shantung railway 175 miles west of Tsingtao. Near it, in some low hills rising out of the plain, iron ore occurs along a contact between Ordovician dolomite and diorite. In ancient times the ore was mined and smelted by using coal, which occurs in outliers of the Carboniferous nearby. These deposits attracted attention while the railway was being built and plans were made to work them and to reduce the ore in blast furnaces to be built within the Tsingtao concession. A company, in which the Krupp interests were concerned, was formed for this purpose. The estimates of reserves

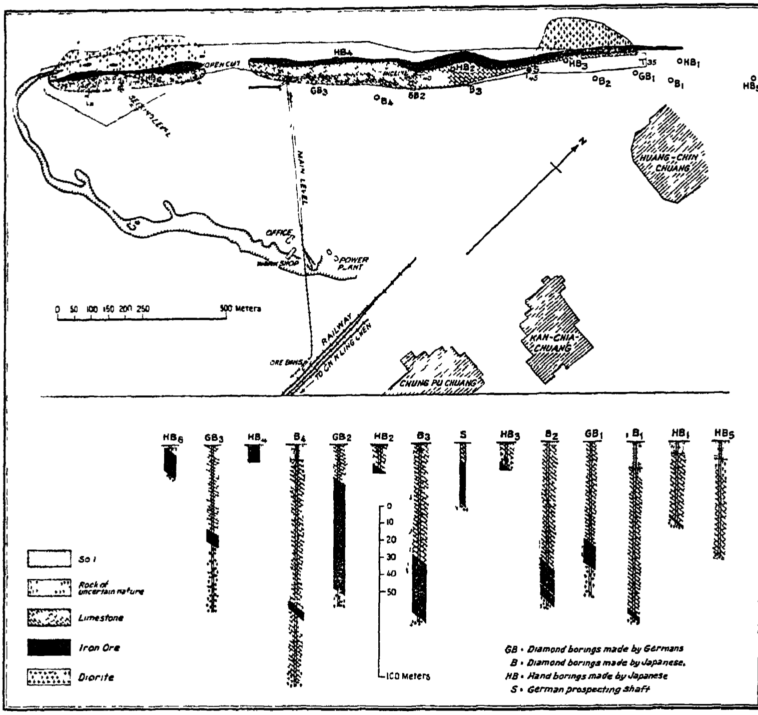

FIG. 14. *Map of T'ieh Shan orebody at Chinlingchen with sketch of ore as shown by drilling. From surveys by "Geological Survey China."*

then made public called for 100,000,000 tons of ore of which 49,000,000 tons was considered fairly definitely assured and 20,000,000 tons easily worked. The analysis given was:

	Percent
Fe	65.00
Mn	0.24
P	0.03
S	0.08

The German plans were stopped by the war and when the Japanese took control it was wisely decided to check the ore estimates by diamond drilling. No complete statement of the results was made public but those that became available, such as an estimate of 17,800,000 tons in the Sze-Pao-Shan deposit, proved later on field examination by Andersson and his assistants[1] to be much too large. As

[1] Tegengren, op. cit., p. 140.

the final result of Andersson's field examination and study of the results of German and Japanese drilling, a probable reserve of 13,700,000 tons of ore in the T'ieh-Shan deposit was allowed and the other occurrences rated as unimportant. The grade of the ore will also, as it appears, prove to average materially below expectations [1] as shown by the following quotation:

"The samples of surface ore have evidently been taken mostly from these rich and hard outcrops which have best withstood the destructive agencies. They show very high iron content (66.51 percent) and low content of sulphur (0.066 percent). At the same time they are low in silica (3.14 percent) which may seem strange at a first glance but is easy to understand, when considering that the silicate (epidote-rock) is more easily destroyed by weathering.

	Surface Ore (Average of 11 analyses)	*Underground Ore (Average of 15 analyses)*
Fe	66.51%	55.27%
S	0.066%	0.66%
SiO_2	3.14%	10.46%

"At deeper levels we get lower content of iron (55.27 percent) and correspondingly higher percentage of sulphur (0.66 percent) and silica (10.46). This is a fact of considerable practical importance. In the early reports the T'ieh-Shan ore was described as exceptionally rich in iron and low in sulphur and silica. But as mining has progressed to some depth below the surface, it has become increasingly clear that the average ore to be mined in deeper levels hardly will exceed 56 percent in iron and that the content of sulphur and silica will probably be about 0.1-0.6 percent and 10 percent respectively."

(The T'ieh-Shan orebody is illustrated in Fig. 14 based upon plates 15 and 16 of Tegengren's atlas.)

Another instance of shrinkage in estimates that may be cited is in connection with the orebodies at Tayeh which form the source of supply for the Han-Yeh-Ping furnaces near Hankow and the new furnaces at Tayeh. These deposits and the enterprise itself have been so fully and

1 Tegengren, op. cit., p. 151.

completely described[1] that it is not necessary to go into details.

The deposit is of the usual type common in the Yangtze valley developed along the contact of a diorite intrusive and limestone which in this case are probably but not certainly of Permo-Carboniferous age. Tegengren cites two estimates earlier than his own made in 1921. One was made

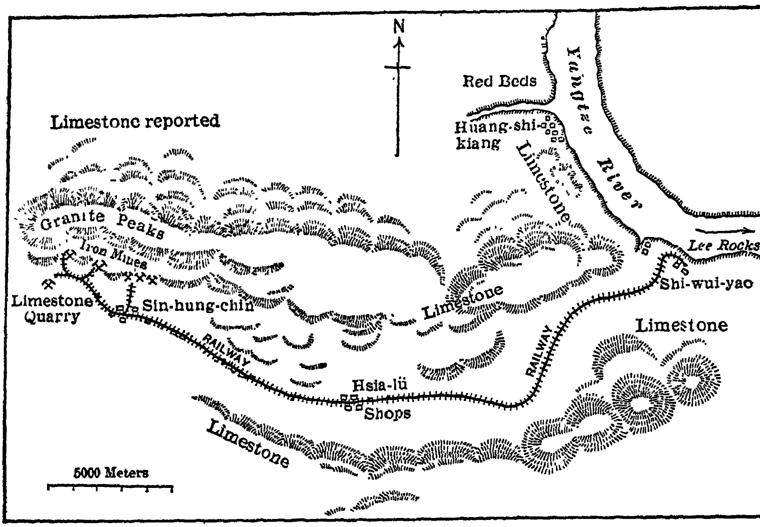

FIG. 15. *Location of Tayeh mine; after Weld.*

in 1911 by Leinung, the German engineer early connected with the enterprise, who placed the reserve at 103,934,375 tons. The other was prepared in 1905 by LeRoy, an engineer then in the Imperial service, and gave a total of 17,910,000 tons. Tegengren's own estimates gave 32,000,000 as the original gross tonnage subject to reduction for rock inclusions and for ore already mined. As a net

1 Read, T. T., "Mineral Production and Resources of China." Trans. A. I. M. E., Vol. XLIII, pp. 28-34, 1912.
Weld, C. M., "The Tayeh Iron Ore Deposits," Trans. A. I. M. E., Vol. XLIV, pp. 27-37, 1912.
Nishikawa, K., "The Tayeh Iron Mine, China." Jour. Roy. Soc. Arts, Vol. LXII, 1914. 1018-1022.
Seltzer, A. J., "The Tayeh Iron Mines, China." Min. & Sci. Press, Vol. 100, p. 546; "Iron and Steel Works at Hanyang, Hupeh, China." Eng. & Min. Jour., 1910, 1231-1234.
Wang, C. Y., "The Tayeh Iron Ore Deposits, China," Trans. A. I. M. E., Vol. LVIII, pp. 445-452, 1918.
Tegengren, op. cit., pp. 181-197.

figure he came to 19,262,000 tons as ore remaining to be mined above water level.

Still another deposit which has given rise to sharp controversy is the Feng Huang Shan and neighboring orebodies near Moling Kuan about twenty miles south of Nanking. These deposits were brought to the attention of the Geological Survey soon after the latter was organized. A topographic map was made by Army engineers and a

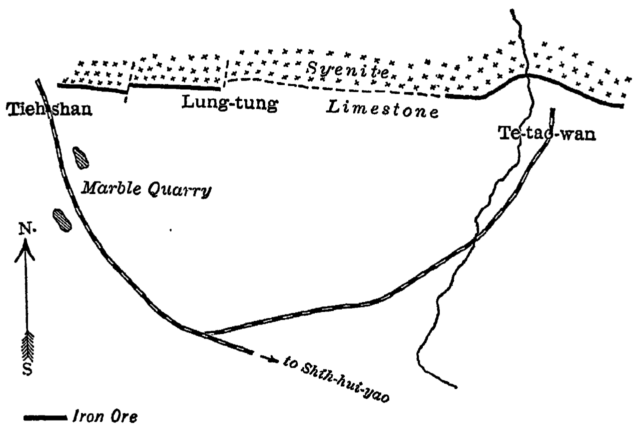

FIG. 16. *Geology of the Tayeh orebody, according to T. T. Read.*

reconnaissance study was made by Andersson. On the basis of area of outcrop and extent above flood plain a tentative estimate of 40,000,000 tons of mineable ore was made. I later visited the deposits but there being no additional data the early estimate was accepted, subject to confirmation by drilling or test-pitting. A sharp controversy as to title ensued and it was not until 1920 that it was possible to make the necessary excavations, when three tunnels and 20 trenches were cut across the orebody by experienced engineers and studied by Andersson and assistants. As a result the tonnage down to river level is now estimated at 4,300,000 of which 2,000,000 is available by open cuts.[1]

Newspaper comment and early Consular reports were full of accounts of large iron ore deposits in the Ankhoe

1 Tegengren, op. cit., p. 250.

district of Fukien but persistent search in 1917 by N. L. Wimmler and George Scarfe, engineers of the staff of the New York Orient Mines Co., failed to find any deposit with a probable tonnage of more than 2,000,000. In one case a mountain of dark porphyry had evidently been mistaken for a "mountain of iron ore."

This uniform shrinkage of deposits when submitted to careful examination and test, can not be without significance. Many more examples might be cited. Such mistakes are not uncommon on the part of unskilled observers, and in the main the knowledge of Chinese ore deposits that has found its way into popular and semi-popular writings has rested on information either far from complete or based upon observations of persons not trained either as geologists or engineers.

Only a small portion of the available data on Chinese iron ores has been here quoted. It is all to be found or is cited in the Tegengren report already mentioned, and on all critical points Tegengren's estimates have been checked by other engineers. The evidence would seem to be conclusive that there is no warrant in present knowledge for the expectation that China will be able to supply iron ore that will contribute to the world's exportable surplus to any considerable degree or even that China can support for any long period a domestic industry consuming steel per capita at a rate comparable to those in Western countries. As Tegengren points out: [1]

> "The total quantity of iron ore (both actual and potential) represented by the figures above would be consumed by the iron industry of the United States within less than nine years."

When account is taken of the larger population of China and the commitments already made to supply ore or pig iron to Japan, it must be clear that China can not go over to any modern basis of industry without importing enormous amounts of steel.

The present iron and steel industry in China has been discussed by many writers but the best summary statements

1 Op. cit., p. 293.

are those of Tegengren[1] and Hoyt.[2] Tegengren described the native furnaces and methods of production and points out the various excellent reasons why they can never be expected to contribute iron to general trade. He lists 16 blast furnaces at 7 plants having an aggregate theoretical daily capacity of 2,700 tons or 900,000 tons of pig iron per year, but is careful to point out that at least two of the stacks are obsolete and that the remining 840,000 tons annual capacity could only be achieved under most favorable conditions. He also points out that pig iron production of recent years has ranged between 200,000 and 300,000 tons and that of this 160,000 to 200,000 has been annually exported to Japan. On the other hand, iron and steel have been imported to the amount of about 300,000 tons per year, making the net domestic consumption 550,000 to 600,000 tons per year.

Hoyt only credited the country with 12 stacks of 100 to 450 tons daily capacity, rating the others as obsolete. He considered that if the furnaces lived up to their capacity, 900,000 tons of pig iron could be made per year, but noted that at the time he wrote, the output was actually at the rate of 180,000 tons. His report and supplements go fully into details as to plant, costs and efficiencies. He considered it doubtful whether any of the Japanese-owned furnaces in China could deliver pig iron at Kobe at less than $38 gold per ton and stated that: "Every furnace now operating in China, should on the basis of cost and relation to selling price, be blown out at once." He found that all the furnaces then running were doing so by virtue of a government subsidy in some form. He also judged that it would be many years before the blast-furnace practice in China and Manchuria would approach the efficiency common and necessary in the United States. He closed his report with the conclusion that: "Until coke is delivered at the furnace stock-house at a cost approaching that in America, China will continue, as she is to-day, a country without a steel industry." This careful study of actual conditions by

1 Op. cit., pt. II, pp. 297-403; especially p. 396.
2 "Blast Furnaces and Steel Mills in China." Lansing W. Hoyt, Trade Commissioner, Bureau of Foreign and Domestic Commerce, Rept. No. 4373. Washington, Aug. 15, 1922.

one familiar with modern steel making is especially worth consideration.

Outside China and Japan, it has already been indicated, there is now no iron and steel making in the Far East of other than local importance. Tegengren has summarized the situation as it existed in 1922 [1] and has given numerous citations to reports on the individual countries. In eastern Siberia, he quotes the reports of Bogdanovich [2] and Tikonovich [3] to the effect that the deposits are few in number and range in size from 1,500,000 to 2,000,000 tons, and the total probable reserve is of the order of 5,000,000 to 6,000,000 tons. In Indo-China, Siam and Malaya, he found no reason to anticipate the discovery of important bodies of iron ore and this checks with the observations of the engineers of the New York Orient Mines Co. and others. This leaves Japan, the Philippines, and Netherlands East Indies to be discussed.

The possible iron ore resources of Japan have been most carefully studied by the Imperial Geological Survey. In the summary prepared for the International Geological Survey Congress by K. Inouyè, then Director, the actual iron ore reserves were placed at 56,000,000 tons in Japan proper and 4,000,000 in Korea. It was then assumed that moderate additional amounts would be found. Writing twelve years later and summarizing all additional data, Tegengren quoted the figures below, though he expressed personal doubts as to the total in view of the failure during the War boom to increase output.

ESTIMATED IRON ORES OF JAPAN

		Tons
Magnetite:	Kamaishi mine, Iwata	35,000,000
	All others	5,000,000
Hematite:	Echigo, Rikuchu, etc.	30,000,000
Limonite:	All	10,000,000
		80,000,000

An attempt is now being made to develop and use certain beds of magnetic iron sand found in the Tertiary deposits of the northern part of Hondu. The deposits are

1 Op. cit., pt. II, pp. 405-416.
2 "Iron Ore Resources of the World," Int. Geol. Cong., 1910, pp. 541-543.
3 *Idem.*, pp. 1261-1265.

found on Kuji Bay in Iwate prefecture and have been known and worked in a small way since 1650. They are now being developed and the engineer, James W. Neill, has recently published certain details[1] from which the following is quoted:

> "The deposits lie in the foothills about five miles back of the town, at an elevation of about 800 feet, and extend for about 15 miles along the foot of the higher hills. They constitute an ancient ocean beach, which has been elevated to its present location. The iron was originally deposited as a magnetite sand brought down by streams to the ocean from some erosion area in the mountains and distributed by wave and current along the ancient littoral. The Tokiwa Company, Ltd., of which Goro Matsukata is president, has prospected the deposit for some 15 miles in length. The greatest width thus far determined is 4,000 feet and the average depth of minable ore about 10 feet, though in places the sands carry good values to depths of 75 feet.
>
> "These iron sands are deposited in layers of varying iron content, the best grade usually being at the top. They lie either upon the bedrock or upon other layers of sand and gravel of little or no value. They carry persistently a small amount of gold. The ore consists of magnetite grains, with much limonite derived partly from the breaking down of the magnetite, together with barren sand, pebbles, and in places boulders of fair size, all well rounded. The grains are very fine, practically all passing 65 mesh.
>
> "The limonite in the ore is also derived in part from the oxidation of the hypersthene, which is quite abundant in the original ore. The magnetite carries about 14 percent TiO_2 and the crystals of ilmenite (rutile?) are so minutely interlaced in the magnetite grains that crushing to 100 mesh fails to effect a separation. The limonite carries from 2 to 5 percent TiO_2 only. In the ground thus far developed the ore carries about 35 percent magnetite, and this contains 40 percent of the total iron; the balance is in the limonite."

The metallurgical problem is complicated by the fact that the iron is in two forms and by the presence of titanium. A process has been developed for meeting these difficulties

1 "Making Iron from Beach Sands in Japan," Engineering and Mining Journal, Feb. 5, 1927, pp. 243-245.

and a plant is now being built. It is proposed to roast the ore, make sponge iron, convert that into briquettes, and in turn make these into steel in open hearth furnaces. Such a series of processes will be expensive though not necessarily fatal to success. The data published do not permit any independent judgment as to the amount of ore available for treatment but, having in mind the difficulties in the technology of making iron from such material and the world-wide experience that such sands are much less abundant than first appearance indicates, there seems no reason to anticipate that the enterprise will do more than supplement the existing iron output of the Empire.

That Japan, the largest consumer of iron and steel products in the Far East, possesses iron ore resources entirely inadequate to her needs, is freely admitted on all sides. Despite this disadvantage the Japanese have made a brave and determined effort to build up an iron and steel industry. The figures of production, imports, and consumption for recent years are given in the table below:

JAPAN'S PRODUCTION AND CONSUMPTION OF IRON AND STEEL [1]

(In 1000 Metric Tons)

	Pig Iron Production				*Imports*		*Exports*		
	Japan Proper	*Korea*	*South Manchuria*	*Total*	*Pig iron*	*Refined iron and steel*	*Pig iron*	*Refined iron and steel*	*Balance available for consumption*
1912...	...	...	...	...	...	...	..	...	....
1913...	240.3	...	...	240.3	265.1	515.9	0.4	11.6	1,009.3
1914...	300.2	...	...	300.2	169.1	387.2	0.2	11.3	845.0
1915...	317.7	...	29.9	347.6	166.8	231.0	0.4	11.8	733.2
1916...	388.7	...	49.0	437.7	232.0	426.8	1.6	14.2	1,080.7
1917...	450.7	...	38.6	489.3	232.2	584.8	3.3	31.1	1,271.9
1918...	582.8	42.7	45.7	671.2	225.1	603.7	1.1	47.3	1,451.6
1919...	505.5	78.4	106.1	780.0	283.2	660.2	1.9	61.2	1,660.3
1920...	521.1	84.1	116.0	721.2	348.6	979.2	2.5	44.6	2,001.9
1921...	475.9	83.0	93.9	652.8	227.1	601.0	..	23.7	1,467.2

It is difficult to make sure of accurate figures covering all the items in such a table as above owing to differences in the basis of the collection of figures and in definition. The table given represents the conclusions of a careful, informed engineer close to the sources of information and reflects the facts with a high order of accuracy. For the succeeding years the Japanese Mine Owners Association

1 Tegengren, op. cit., p. 410.

give the following figures for pig iron production, presumably including Korea and Manchuria: 1922, 642.4; 1923, 710.6; 1924, 698.2, thousands of metric tons.

There is a theoretical furnace capacity in Japan for making about 1,500,000 tons each of iron and steel. In 1924,[1] the actual production of pig iron was 698,000 tons and of steel 906,000. The largest plant is the Yawata, near Moji, owned by the government and including five blast furnaces having an aggregate capacity of 400,000 tons, and a steel plant of 525,000 tons capacity together with various finishing plants. There are also the Kamishi iron and steel works, the Nippon, the Sumitomo, the Kokura, the Mitsubishi and others in Japan proper, and the Anshan, Penhsihu, and Tayeh in China. The furnaces in Japan draw ore from domestic mines and also import from Korea, China, Malaya, and at times from the Philippine Islands. The individual furnaces are smaller than is usual in the United States, they are driven at a slower rate and the whole industry is scattered among a larger number of units for the total output. The present steel-making capacity of Japan is smaller than the actual output of Luxemburg which was credited with 2,192,700 tons in 1926, and if all the plans proposed in the period of most rapid expansion during the war were realized and an output of 3,000,000 tons per year built up, it would still be less than the present actual output of Belgium, 3,313,400 tons. Such an output would be but a modest one for a country situated as is Japan and would constitute no serious threat to business competitors. Such information as is available gives no suggestion that Japan can manufacture for export or will cease to be an importing nation if even the present degree of conversion to a metal-using basis of industry is maintained. If the country comes to rival Western nations in iron and steel consumption per capita, large quantities must be imported.

The iron ores and iron industry of the Philippine Islands have been summarized by Smith.[2] The ores themselves

1 "Mining in Japan," Asso. Mine Owners, 1926.
2 "Geological and Mineral Resources of Philippine Islands," Manila, 1924.

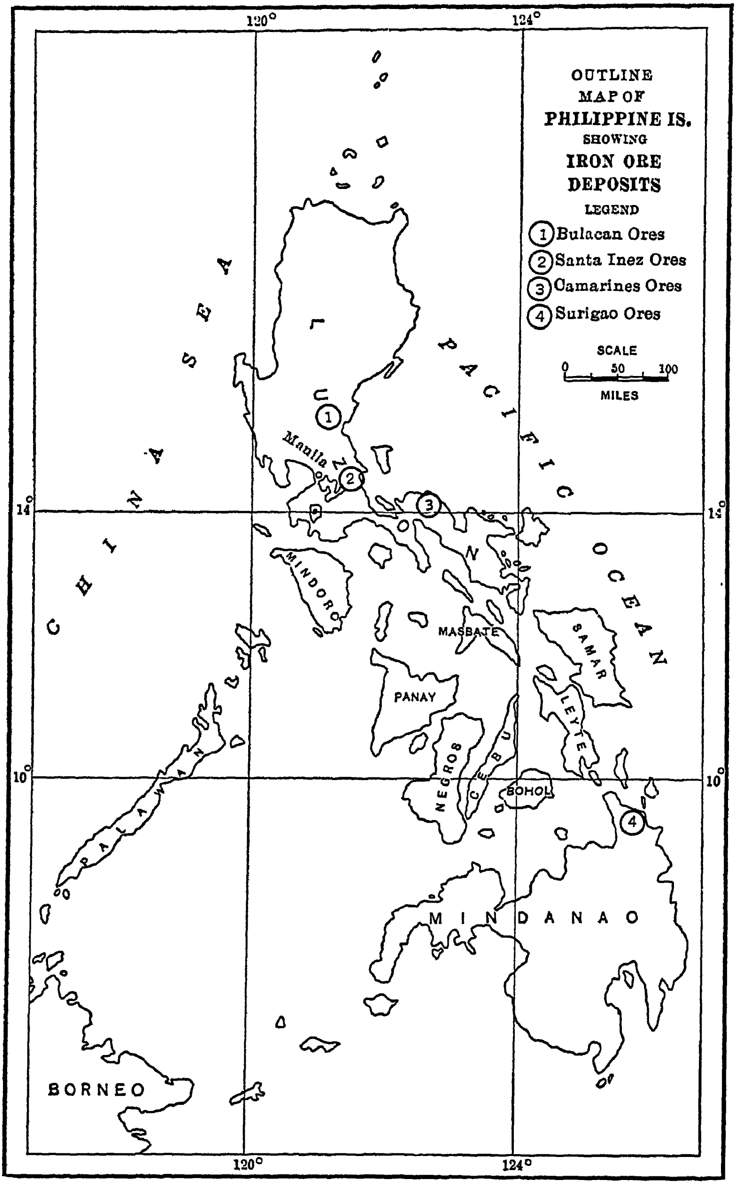

FIG. 17. *Map of the Philippine Islands, showing location of principal iron ore deposits; after Wallace E. Pratt.*

were described in 1916 by Wallace E. Pratt[1] and reference will be here made to the latter paper, which includes citations to all previous descriptions. After referring to earlier statements to the effect that the Cordillera of Luzon was extremely rich in iron, Pratt says:

> "To-day, however, it is recognized that the iron-ore deposits in the Eastern Cordillera of Luzon constitute, not a continuous belt, but a series of widely separated deposits, including a half-dozen orebodies within a distance of 10 miles in Bulacan Province, a single outcrop at Santa Inez, Rizal Province, farther south, and three deposits around the margin of the Mambulao-Paracale gold-mining district in Camarines Province, 100 miles farther to the east-southeast. Other unimportant occurrences of magnetite-hematite areas are known, but the foregoing, together with the lateritic ores of Surigao Province, Mindanao, contain the economically important iron-ore reserves of the Philippines."

Discussing the magnetite-hematite ores, he describes the various individual deposits, presents the evidence for ascribing their origin to metamorphism resulting from the intrusion of igneous rocks—of the same type, by the way, as have caused the formation of the various deposits of the Yangtze valley already described—gives analyses showing a usual content of more than 60 percent iron, low silica, sulphur and phosphorus, and then has the following to say as to the present quantity of the ore present:

> "It will be obvious from what has been said that no accurate estimates of quantity can be made for the magnetite-hematite ores. Dalburg and Pratt,[2] basing their estimate solely on the outcrop dimensions and assuming that the orebody would continue in depth a distance equal at least to surface dimensions, obtained 1,100,000 tons for the Camaching deposit. The other Bulacan deposits probably aggregate at least 100,000 tons. While the assumption as to the persistence of the ore in depth is conservative in view of the character of the mineralization believed to have caused these deposits, yet the data available are insufficient to make the estimates reliable. . . . For the

1 "The Iron Ores of the Philippine Islands." Trans. A. I. M. E., LIII, pp. 99-105.

2 Reference is to "The Iron Ores of Bulacan Province, P. I.," by F. A. Dalburg and Wallace E. Pratt. Philippine Jour. Sci., Vol. III, Sec. A., p. 201.

deposits of ore in Rizal and Camarines no estimate of quantity can be offered. The Calambayanga deposit appears to be large; probably 100,000 tons are represented in the blocks of ore on the surface."

The lateritic iron ores of Surigao province in Mindanao, whose importance was first recognized by H. F. Cameron in 1914, are described by Pratt in considerable detail. They occur near the sea and are strikingly similar to the Mayari ores of Cuba.[1] They form a surface blanket of residual clay varying in thickness up to 60 feet and resting upon the parent rock, here as usual, serpentine. The ore is a spongy or mealy clay but over its surface are numerous small red concretions, together with occasional porous fragments or crusts of the parent rock. The composition appears to be slightly inferior to ores of the same character in Cuba; but by nodulizing or sintering, it should be possible to produce a furnace ore of a content of 52.5 percent metallic iron. The ore occurs over an area of 40 square miles and of this 28 square miles was sampled, 98 drill holes being put down. Pratt gives the details of this work and then says:

"From these figures and the weight of a unit of volume of the ore in place it can be calculated that the total economically important metric tonnage is 430,000,000, of which about 375-000,000 tons is contained in that part of the ore mantle which is 10 feet or more in thickness. Reasonably accessible from the coast, but divided into a number of separate deposits by precipitous valleys, there is 275,000,000 tons of ore, with 260,000,000 tons lying 10 feet or more deep. Finally within the two areas of ore which could be mined from a base at Dahikan Bay, the most feasible harbor site, there is 138,000,000 tons, 130,000,000 tons of which is more than 10 feet thick. It should be noted, however, that the bulk of even this most favorably situated ore lies on the tops of the hills and broad divides from 400 to 1,000 feet above sea level and that within each of the two areas near Dahikan Bay there are ravines and denuded slopes which would of necessity be avoided in mining."

1 See J. F. Kemp, "The Mayari Iron Ore Deposits, Cuba," Trans. A. I. M. E., Vol. LI, pp. 3-30, 1915. Also, C. K. Leith and W. J. Mead, "Origin of the Iron Ores of Central and Northern Cuba," Trans. A. I. M. E., XLII, pp. 90-102, 1920.

From these figures it is evident that there is available in the Philippine Islands a quantity of iron ore of commercial grade of world importance. Unfortunately, the coal supply of the Islands is deficient; and if the general rule of industry be followed here as elsewhere, it may be anticipated that the ore will be shipped to coal rather than the reverse and, accordingly, that while the Philippine iron ores may contribute to the industrial well-being of the Far East they are not likely to result in a major steel industry in the Islands. As already noted, ore has already been shipped at times to Japan. The general limitations on working lateritic iron ores will be discussed later.

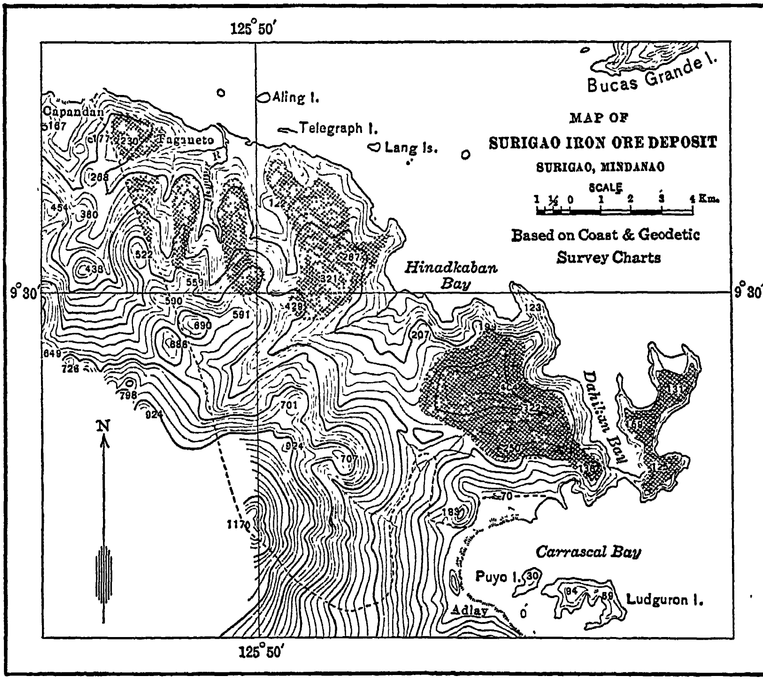

FIG. 18. *Map of the Surigao Iron Ore Deposit; after Wallace E. Pratt.*

In the Netherlands East Indies, iron ore is known to be present in large quantities. Molengraaf[1] in 1910, called attention to magnetic iron sands, to a lode of magnetite in

[1] "Iron Ore Resources of the World," Int. Geol. Cong., p. 903

schist in Sumatra, and to the lateritic iron ores on Surinam and other islands. The probable reserves of ore in the magnetite lode was placed at 50,000,000 tons and the importance of the lateritic deposits was not then recognized. The deposits are described in various reports of the Netherlands Indies government in Dutch but a convenient brief summary is available in English, the deposits having been described in one of the lectures delivered by H. A. Brouwer, exchange professor at the University of Michigan in 1921-22.[1]

Brouwer noted that the contact deposits, found in the western islands, show relations to grano-diorite intrusives, just as elsewhere in the Far East. The quality of the ore is, as usual, favorable but the tonnage moderate. The big reserves are of lateritic ore and of this he states that the total quantity present has been estimated at 1,000 million tons but that more deposits have been discovered since that estimate was made. He gives details as to tonnage and grade of various individual deposits and states that the ores are similar in character, as analyses show them to be in quality, to the lateritic iron ores of Cuba. The ore occurs abundantly in the lake region of Central Celebes, and on the island of Strait Laut and northeastern Borneo. In the Celebes the largest known deposit is the Larona of which the average thickness is 37 and the maximum 70.5 feet. In a total of 373,000,000 tons 12,000,000 occurs as hard surface ore. In Strait Laut the deposits on the island of Sebuku are estimated to contain 300,000,000 tons. On Survangi, 20,000,000 tons is found and in the neighboring fields of Borneo, 120,000,000 tons. While neither here nor in the Philippines has the prospecting been complete and the estimates may shrink slightly in further study, the occurrence is of a type that warrants expectation of the presence of large tonnages.

The Government is now attempting production from these ores by the process of making sponge iron and converting it into steel in an electric furnace, under the advice of M. H. Caron, an experienced metallurgist. The essentials to such work, iron ore, coal (though of low grade) and

[1] "The Geology of the Netherlands East Indies," Macmillan Co., 1925, pp. 100-104.

abundant water power are available and the experiment is being watched with much interest. The difficulties have already been mentioned. It remains to point out that lateritic iron ores, wherever found, are handicapped by the fact that they contain much moisture, the Larona soft ore contains 40 percent, and this must be driven out before the ore is usable. In Cuba this is done by a special preliminary process of nodulizing or sintering which adds to the cost but greatly reduces the weight to be shipped. Lateritic ores also contain notable amounts of minerals other than iron, especially nickel and chromium. While for some purposes these metals add to the value of the steel made from the ore, for other purposes they decrease its value and in all cases their presence adds to the complications of the steel-making process. For these various reasons lateritic ores, despite their mode of occurrence which favors cheap mining, do not often compete effectively in the market with good hard ore. The great deposits of these ores found in the Far East and elsewhere are of real importance to the world, but only under exceptional combinations of circumstances will steel be made from them as cheaply as from ores of other and more common types.

CHAPTER IV

PETROLEUM IN THE FAR EAST

By W. B. Heroy

BECAUSE of the rapid growth of industrialization in Japan and the increasing fuel requirements of that country, the search for oil in the empire has been as intensive as in any other part of the world, and a number of petroleum fields have been developed. These are situated principally along the coast of the Sea of Japan, where there are now over 20 separate areas. The total number of producing wells is somewhat over 3,000. The daily average production in recent years has been about 6,000 barrels, so that the average daily production per well is under 2 barrels. Total production for recent years is as follows: 1923, 1,791,300 barrels; 1924, 2,210,853 barrels; 1925 (estimated), 2,000,000 barrels. The total production from the beginning of development is about 50,000,000 barrels.

Oil has thus far been found only in geologic formations of Tertiary age. The areas of Tertiary sedimentary rocks are chiefly confined to a belt bordering the western margin of the archipelago, where the oil occurs in the main in anticlinal structures with a trend parallel to the general coast line. Outside of this Tertiary belt, in the central and eastern parts of the islands, the geological conditions are distinctly less favorable for oil accumulation. That large areas of volcanic rocks exist is common knowledge; and most of the areas of sedimentary rocks older than the Tertiary have been closely folded and are more or less metamorphosed. The presence of oil deposits in rocks of this character is improbable and these regions cannot be regarded as containing commercial oil reserves.

Outside of the Japanese archipelago proper a little oil has been found in Taiwan (Formosa). The output has been very disappointing and the discovery of any large fields

in this island is improbable. Japanese Sakhalin (Karafuto) contains some areas of Tertiary rocks, but these are closely folded. The older rocks are for the most part metamorphosed, so that the Japanese portion of the island gives little promise of oil production.

In Korea, Japan possesses a dependency which is composed almost entirely of crystalline and metamorphic rocks. It has been thoroughly explored and there is no expectation of its becoming a source of petroleum.

The Tertiary areas of the Japanese archipelago must, therefore, be regarded as Japan's main reliance for future home supplies of petroleum. These resources consist of (a) unexhausted horizons of present producing fields; (b) undiscovered deeper horizons in structures now producing; (c) undiscovered fields.

Present production is obtained from four principal districts—the Echigo, Akiti, and Totomi districts in the island of Honshu, and the Hokushu district in the island of Yezo. The production in the two latter areas is unimportant, totaling less than 100 barrels per day. Each of the other two districts produces about half of the total output.

Reserves of petroleum in unexhausted horizons of present producing fields were estimated by Redfield to be about 56,000,000 barrels at the end of 1924. The greatest depths to which wells have been drilled in Japan is only a little over 4,000 feet, so that there is still probability that deeper producing horizons will be discovered in present fields. With the improvement of exploration methods other fields will doubtless also be discovered in the areas of Tertiary rocks, but the extensive exploration work and wildcat drilling which has been done in recent years without important new discoveries suggests that in this respect less may be expected in the future than has been accomplished in the past. The introduction of geophysical methods of exploration may assist discovery to some extent, although in general structural conditions are not obscure. While estimates of future recovery have little or no quantitative value, it would be surprising if the ultimate total production of petroleum from all sources were to exceed ten times the amount produced to date, say 500,000,000 barrels.

For a country of large population, which is rapidly becoming primarily industrial, the petroleum resources indicated are extremely meager. The total annual production of Japan is approximately the same as the average daily production of the United States. The total per capita consumption of petroleum products is less than three gallons, and of this amount over fifty percent is now imported. The above figures do not take into account oil purchased abroad for bunkering the Japanese Navy, an amount probably much larger than the entire domestic consumption. The need for additional petroleum products has been an incentive for the Japanese to explore for petroleum in territories outside the empire but within the sphere of Japanese economic influence. The available sources of information regarding Japanese oil fields are listed below.[1]

The area of China is so vast and the regions which have been geologically mapped are in comparison so inextensive that any endeavor to assess its potentialities as a producer of petroleum is necessarily hazardous. Much of the earlier geological work was done by men who were not specialists in petroleum geology and whose results must in consequence be interpreted in the light of present knowledge of the principles controlling the occurrence of petroleum. The most critical studies of its possibilities in this direction that have been made were those of Fuller and Clapp in North China and G. D. Louderback in Szechuan for the National Oil Bureau supported equally by the Chinese Government and the Standard Oil Co. of New York. While their reports have not been published in full their conclusions are well known.

In a country so little explored and where so few have had experience in modern oil production, inaccurate statements and exaggerated hopes not unnaturally abound. Writing of this phase of the matter, Fuller and Clapp said:[2]

[1] Clements, J. Morgan, "Petroleum Resources of Japan." Trans. A. I. M. E., Vol. XLVIII, pp. 1097-1104. 1923.
Coumbe, Albert T., Jr., "Petroleum in Japan." Bureau of Foreign and Domestic Commerce Trade Information Bulletin No. 285. June 30, 1924.
Imperial Geological Survey of Japan, "Geology and Mineral Resources of the Japanese Empire," pp. 98-103. Tokyo. 1926.
Redfield, A. H., "The Petroleum Supply of Japan." Engineering and Mining Journal-Press, Vol. 20, Nos. 9-11, August-September, 1925.
[2] M. L. Fuller and Frederick G. Clapp. Economic Geology, Vol. XXI, p. 743, 1926.

> "Petroleum seepages were reported by Chinese officials and others from scores of localities in Shansi, no less than forty being said to occur in the region of the capital, Taiyuanfu, alone. Notwithstanding, however, careful search by half a dozen geologists and the running down of every report coming to their attention, not a single seepage was found within the limits of the province. Nowhere in the world are circulating rumors more widespread or wilder in their flights of imagination than in China. Referring to petroleum again, but in another part of the country, a deluge of most persistent reports came from localities hundreds of miles apart, but in the end were found based on a single occurrence of oil shale in pockets only a few rods in probable extent."

In spite, however, of the difficulties and the relatively meager knowledge available, enough is known of the general geology of large portions of China to make it possible to indulge with some safety in generalizations with reference to their petroleum prospects. Other areas, and these perhaps the most promising in China, have been examined by competent petroleum geologists, and their conclusions have become available. In the following review only that part of China east of the 100th meridian is considered. Western Mongolia and Tibet are too distant for any petroleum that they may contain to be an economic factor of importance in the Pacific area for generations to come. China proper, Manchuria, and Eastern Mongolia are all within the scope of this discussion.

Considered broadly, China is a country of older rocks. If the purely superficial deposits, such as the loess, are excepted, most of the formations exposed at the surface and constituting the bedrock geology are of Paleozoic and pre-Paleozoic age. From the close of the Paleozoic to the present most of China has been continuously a land area. Beds of Mesozoic age are confined to a few basins surrounded by the older rocks. The coastal plain and the great valleys consist of sediments of Pleistocene and recent age laid down horizontally upon an irregular surface of older rocks.

The Archean or pre-Paleozoic rocks of China, like those of most other portions of the world, are highly crystalline.

In China, rocks of this age make up the cores of the mountain ranges, but there are in addition other regions where the Archean rocks are the dominant surface formation. Rocks of this character do not yield petroleum and search for it in them is useless.

The Paleozoic formations of China are more widely distributed than those of any other era. In the main they consist of limestones, sandstones, and slates. The entire Paleozoic section has a great thickness and each Paleozoic period is represented. In South China the section consists chiefly of limestones, which here attain great thicknesses. In the north, in addition to the limestone series, rocks of Carboniferous and Permian age, chiefly sandstones and coal measures, add to the thickness of the section.

As practically all the Paleozoic rocks of China are of sedimentary origin and as rocks of this age are important sources of petroleum in other parts of the world, the presence of such large areas of Paleozoic rocks suggests that China may also have petroleum deposits of magnitude. There are, however, three sets of facts which have an adverse bearing on such a conclusion.

From a stratigraphic standpoint most of the earlier Paleozoic rocks of China consist of massive limestones of great thickness. The general presence of important bodies of bituminous shales, which might form source beds for petroleum, is unknown. Limestones and sandstones which might act as reservoirs for petroleum must in general be associated with large thicknesses of shale in order that the conditions may be favorable for the accumulation of petroleum. While, therefore, the presence of these great limestone formations might at first be construed as a factor favorable to the existence of petroleum, the absence of shales interbedded with them greatly detracts from these possibilities.

The second consideration is the general structural relations. Throughout much of China, the dominant type of geologic structure is the fault block. Faults of great magnitude form lines of separation between great blocks of strata. The movement along the fault lines causes discontinuity of the beds and breaks up the formations in such a manner

that the conditions created are unfavorable to the accumulation and retention of petroleum.

Over large areas, also, in rocks which otherwise might be considered as potential oil sources, the regional metamorphism has progressed so far that whatever oil may have been originally contained in the strata must have been expelled. The degree of this metamorphism may be tested by determining the ratio of fixed to volatile carbon in the coals. Such analyses as have been made of Chinese coal suggest that in most parts of the country the carbon ratios are too high for petroleum to be present. In areas where coal is not present observers have noted that the limestones have been subjected to metamorphism so that all gradations are found from moderately crystalline limestone to marble. When limestones have been metamorphosed to this degree petroleum may not be expected to be present in any quantity in them.

Having the above generalizations in mind, the possibilities in China may now be discussed from the standpoint of the actual work that has been done to determine the presence of oil. During the last two years the results of important explorations in China have been made public. Members of the Chinese Geological Survey have contributed several articles. Messrs. Fuller and Clapp, who spent the period 1913-1915 in oil exploration in North China, have published reports of the work of the six geological parties which they have directed. The Fuller-Clapp expedition worked in the provinces of Chihli, Shansi, Shensi, Kansu, and Northern Honan. Altogether some 20,000 miles of geological traverse were run in this area, all by men of extensive experience in petroleum geology. In the following paragraphs the information contained in their report is summarized.

The only evidences of petroleum obtained in Chihli were small and scattered areas of oil shale. The rocks of the province are mostly crystalline, those of sedimentary origin occur in small and scattered areas, and there is no hope of commercial oil production. In Shansi many reported occurrences of petroleum were investigated without result. The rocks of this province are greatly folded and the carbon

ratios are high. It is highly improbable that a petroleum-bearing field will be discovered in Shansi.

The North Shensi basin, comprising a narrow strip along the western margin of Shansi, the northern part of Shensi, and northeastern Kansu and a part of Southern Mongolia, is the most favorable region in North China for petroleum development. The basin contains an area of over 100,000 square miles and includes rocks from Cambrian to Jurassic in age, overlying unconformably pre-Cambrian rocks. Oil seepages occur and a definite possibility of developing commercial fields exists in this basin. The province is not likely to be an enormous producer. Structural conditions are not in general favorable to large output. Drilling operations have been conducted by Chinese and American capital. Ten wells have been drilled, of which two near Yen Chang proved productive. The Chinese Bureau of Mines reports an output of about 2,500 barrels in 1917, the largest of any Chinese oil field.

The portion of the province of Kansu west of the Shensi basin has some oil possibilities, but conditions are apparently much less favorable than those in the basin. The other northern province, Shantung, is a region of old rocks, mostly crystalline and metamorphic.

The eastern and southern provinces have not received the same attention from petroleum geologists as have those of North China, chiefly for the reason that in a general way the conditions are less favorable for the presence of commercial deposits of the mineral. No detailed reports are available and conclusions as to the petroleum resources of these areas must be drawn from general information concerning the geology.

The plains areas of eastern China are composed of very recent sediments, lying horizontally on a basement of older rocks. These sediments are chiefly alluvial silts which are unlikely to yield petroleum. The provinces of Kiangsu, Anhwei, Honan and Hupeh lie principally in the plains. No indications of petroleum have been reliably reported from the hill portions of Honan and Anhwei and in general the geology of these provinces is unfavorable to its occurrence.

Such geological work as has been done in the six south-

ern provinces makes it appear evident that little if any petroleum may be expected in this great area. Blackwelder concisely summarizes the facts as follows:

> "The southeast quarter of China consists entirely of pre-Cretaceous rocks, all strongly folded and faulted, and invaded by igneous intrusions. The probabilities of finding oil in this region would seem to be no better than in the barren Appalachian mountains." [1]

Next to Shensi the most important petroleum deposits thus far discovered in China have been found in the western province of Szechuan. This region has been geologically examined for the Chinese Government by a petroleum geologist. The oil-bearing rocks are of Mesozoic age, occurring in a basin surrounded by Paleozoic rocks. Anticlinal structures occur in the Kiating and Tzuliuching districts. The Mesozoic rocks of the region contain salt beds, and in the process of mining the salt oil has been encountered in a number of wells. Some of these wells have been carried by primitive methods of drilling to depths of over 4,000 feet. About a dozen wells have produced sufficient oil to justify its recovery, the oil floating on top of the brine in the wells. The total production is small, probably less than a barrel a day. The region may produce oil in considerably larger quantities, if modern methods of petroleum development should be employed.

Yunnan, the southwestern province, has been thoroughly explored by British and French geologists. In the western part of the province extensive areas of crystalline rocks occur. The central and eastern parts of the province are regions of sedimentary rocks, structurally disturbed by profound folding and faulting. Coals, which occur in the Carboniferous and Triassic, are characterized by high carbon ratios, and this fact would probably preclude the existence of petroleum. The papers on the mineral resources of the western part of the province, by J. Coggin Brown, do not mention petroleum, and in various traverses of the province by American geologists no true seeps of oil were observed.

1 Trans. A. I. M. E., Vol. XLVIII, p. 1106, 1923.

In summary, therefore, it may be said that only two areas in China proper seem to have possibilities of commercial petroleum production, and in neither of these can we feel at all certain of the development of a field of the first magnitude. Nowhere in China do conditions exist which are comparable from a geological standpoint with those existing in the mid-Continent or Pacific oil fields of the United States. Making every allowance for deficiencies in present knowledge of the economic geology of China, its oil reserves are still probably less than one percent of those of the United States.

The vast plateaus of Mongolia have been almost unknown geologically, until the results of the recent expeditions of the American Museum of Natural History were made available. The work of the geologic staff headed by C. P. Berkey shows that eastern Mongolia is a plateau region bordered on the east and southeast by a great escarpment. The basement rocks of the plateau are much folded and faulted and regional metamorphism is far advanced. The region underwent extreme peneplanation after this period of folding, and over immense areas these older rocks have been smoothed down to an essentially level surface. On this surface there have been deposited in parts of the region areas of younger rocks. These rocks are not, however, of marine origin but are terrestrial deposits formed chiefly under arid conditions. Neither series of beds, the older basement rocks or the younger sediments, seems to hold forth any possibility of being a source of petroleum.

Eastern Manchuria is similar geologically to the neighboring regions of Shantung and Korea, in that it is composed of older rocks with complicated structure. Basins of younger rocks occur, among them coal measures, but again the carbon ratios seem higher than could be associated with the presence of petroleum. On the other hand extensive areas of oil shale are reported, which would suggest that in some parts of the province regional metamorphism is low and that this factor is favorable to oil accumulation. Oil seepages are not, however, reported from the region and the present weight of evidence is against the existence of important oil fields.

The geology of French Indo-China has been intensively studied by the Geological Service of Indo-China,[1] which has published extensive monographs on this subject. From these publications it appears that Tonkin is for the most part an area of granitic and other crystalline and metamorphic rocks which are closely folded and greatly faulted. A few Tertiary basins have been discovered, but these have been very deeply dissected by erosion. Tonkin holds very little promise as a source of petroleum.

Knowledge of the petroleum resources of the Philippine Islands is contained mainly in the reports of the Philippine Bureau of Science, chiefly by Messrs. W. D. Smith and W. E. Pratt. Petroleum seeps in the Philippine Islands have been known since 1890 and as early as 1898 efforts were made to obtain petroleum by drilling. After the American occupation, the Geological Survey of the Islands was instituted and evidence of widely distributed petroleum deposits was gradually collected. On all of the ten larger islands of the Philippine group, except on Palawan, there are definite indications of the presence of oil. Luzon, Leyte, Cebu, Mindanao, and Panay have definite oil seepages and gas seepages, and oil shales occur in the other larger islands as well as in many of the smaller islands. Although there are large areas of volcanic rocks in the Islands, Tertiary strata, shale, sandstones and limestones also are widely distributed. These latter rocks are of the same geologic age and character as the petroleum-bearing rocks in the Dutch East Indies to the south and in Formosa and Japan to the north. The principal source of oil in the Philippines is a group of shales, with included limestone and sandstone beds, which have been called the "Vigo" shales. It is from these shales that the seepages exude. Pratt has estimated that these oil-bearing rocks are present over a probable total area of from 10,000 to 15,000 square miles. The shales are 3,000 feet or more in thickness and of suitable character to supply commercial quantities of petroleum.

[1] Bourret, René, "Etudes Géologiques sur le Nord-Est du Tonkin," Bulletin du Service Géologique, Vol. XI, Part 1. The above publication contains the bibliography of publications relating to the geology of Tonkin.

Actual areas where petroleum is known to exist are, of course, much more limited. On the Bondoc Peninsula in Luzon showings of oil, including a number of seepages, occur over about 300 square miles. In other parts of the Islands an additional 200 square miles of oil-bearing rocks are believed to be present, making a total area of some 500 square miles. Geologic mapping indicates that the oil-producing areas have been folded into anticlines and thus are structurally favorable for oil accumulation. The quality of the oil, as determined by samples, appears to be high.

On the basis of the geologic investigations above described and after the passage in August, 1920, of a petroleum leasing law, the Richmond Petroleum Company, an American corporation, commenced drilling operations in the Bondoc Peninsula. The company continued its operations for a period of about four years and in July, 1924, announced that it had abandoned its operations after an expenditure of approximately one and a quarter million dollars. During that period three wells were drilled.

> "The first hole went to 1200 feet and was abandoned on account of mechanical trouble: no oil. The second was drilled to 3750 feet: no oil. The third, the final great effort, went down to a depth of 5120 feet, almost a mile: no oil—and the end." * * * * "The failure to find oil at Bondoc does not prove that there is no oil in the Islands: it means that there is none in the area prospected. There is oil to the north in Japan and to the south in Borneo, and it may yet be found in the Philippine group where there has been only one real drilling campaign—the one just finished." [1]

Although these drilling operations tested what was regarded as the most favorable area in the Philippine Islands and, in the opinion of the company, proved that oil was not present in that region, there still remains the possibility of commercial production. The results of this test are discouraging but cannot be regarded as conclusive.

Pratt estimated the possible ultimate production of the Philippine Islands at 52,500,000 barrels. The work done

[1] Standard Oil Bulletin (California), July, 1924.

by the Richmond Petroleum Company would suggest that this figure should be revised downward, but there still remains the possibility of important petroleum deposits in the Islands. The petroleum consumption of the Philippines is approximately 1,968,000 barrels per year. The principal sources of information are listed below.[1]

The geology of Siam has been thoroughly studied by a petroleum geologist employed for two years by the Siamese Government. In Siamese Malaya and in most of the drainage basin of the Menam River, the Paleozoic rocks are metamorphic. In Northeastern Siam there are thick beds of Triassic sandstones gently folded, as well as limited basin deposits of more recent beds. The only definite indications of petroleum discovered in Siam are some tar seeps in the extreme north. There are no known source beds in any of the rocks exposed at this locality and the source of the oil is problematical. Structural conditions are favorable in some parts of the Triassic area, but no source beds are known and there are no indications of oil in the Triassic.

The Netherlands East Indies now rank fourth among petroleum producing countries, with an annual output of 22,500,000 barrels in 1925, representing an increase of 10 percent over that of the previous year. They contributed that year 2.1 percent of the world's output. In the opinion of petroleum geologists and engineers, the fields are capable of considerable expansion and extensive areas remain to be explored. Development is largely in the hands of one company and less has been published regarding the fields than is usual. H. Albert Brouwer, in his lectures at the University of Michigan in 1921-22 [2] gave a brief summary of the geology of the fields.

The principal fields are in Sumatra, Java and Borneo, and the oil comes from beds in later Tertiary age occurring

[1] Pratt, Wallace E., "Possible Petroleum Reserves of Philippine Islands." Trans. A. I. M. E., Vol. LXVIII, pp. 1091-1096. 1923.
Pratt, W. E., and Smith, W. D., "Geology and Petroleum Resources of the Southern Part of Bondoc Peninsula, Tayabas Province, P. I." Bulletin, Journal of Science, section A8 (1913), p. 301. "Philippine Oil Matters Reviewed." Oil and Gas Journal, May 6, 1921.
Pratt, Wallace E., "Occurrence of Petroleum in the Philippines." Economic Geology, April-May, 1916.

[2] "The Geology of the Netherlands East Indies," 1925, p. 118.

in a deep geosyncline or major downward fold of the rocks. There is a close relation of the oil to structural features. The fields are in a structural continuation of those on the Irrawaddy river in Burma. Oil springs, natural gas and mud volcanoes are also known at various points in the eastern part of the Archipelago, but petroleum is exploited only in Ceram. In much of the region there has not been sufficient exploration to furnish reliable data as to the possibilities for the future. Both heavy and light oils are found, and an extensive refining and distributing business has already been built up.

Too little is known regarding the detailed geology of Eastern Siberia to warrant any estimates of the oil resources of the mainland. There is a certain amount of evidence of petroleum in the Paleozoic rocks and, as these cover wide areas, the possibilities may be considerable. In the more restricted area of Mesozoic rocks oil springs and seepages are known—as, for example, in the Irkutsk-Lake Baikal region and on the Upper Amur, and one may reasonably expect to see oil fields developed in this interior region when the economic conditions warrant.

Oil springs are known on the western side of the Kamchatka Peninsula in Tertiary rocks which extend over a considerable area north and south, and there are possibilities of fields there.

However, the most important petroleum area and the one offering the greatest potential possibilities lies in the Island of Sakhalin. For many years the existence of large lakes of oil and oil residue, gas springs and oil springs, has been known along the eastern coast of the island. Following the Russo-Japanese war, the portion of the island south of latitude 50 degrees north was transferred to Japan by the Treaty of Portsmouth. This portion, however, proved to be composed almost wholly of Paleozoic and metamorphic rocks, and to have practically no oil possibilities. The northern or Russian half, covering an area of approximately 16,000 square miles is composed almost wholly of Cretaceous and Tertiary strata. These have an aggregate thickness in excess of 6,000 feet, and duplicate in many

respects the conditions found on the western side of the San Joaquin Valley in California.

The first attempt to develop the northern Sakhalin area was made in 1892, and between that time and the outbreak of the Great War nine shallow wells were drilled, ranging in depth from 300 to 900 feet, and a small amount of oil was secured.

The area was occupied by the Japanese in 1920, and since that time development operations have been carried on, for the most part with great secrecy, by or on behalf of the Japanese Government. The best information available indicates that up to the middle of 1925 the Japanese had sunk thirty-one test wells, of which thirteen were less than 500 feet in depth, and only six were over 1,000. Five of the wells are reported as dry, seventeen as showing oil, and nine as producing oil in commercial quantities. The Government geologist of the Imperial Japanese Geological Survey reports that "some of the wells have erupted 300 barrels per day." The production secured has been used to supply fuel oil for Japanese destroyers.

The prospective oil region extends not only for three hundred miles along the eastern coast of the island, but also down the western coast to a short distance north of Alexandrovsk.

David White, in a paper before the First Pan-Pacific Commercial Conference held in Honolulu in 1923, stated that "an estimate of 1,300 to 3,300 million barrels of oil for Eastern Siberia, including Northern Sakhalin, may not eventually be found excessive."

CHAPTER V

SULPHUR AND THE SULPHIDES

THE fundamental importance of sulphur has already been stated. Without sulphuric acid our whole chemical industry would be impossible, and to make that acid either native sulphur, or the element combined with one of the metals, is required. In an experimental way and to a limited extent the acid has been made by breaking down gypsum, and it is possible that at some future time that material may become an important source of supply; but so far as present knowledge goes, it is impossible to make acid by this process in quantity and at competitive costs.

The world's market for sulphur is now mainly supplied from the wells in Texas, supplemented by sulphur mined from sedimentary beds in Sicily and that derived from treating sulphide ores of the various metals, particularly the iron-copper pyrite from southern Spain. Locally, sulphur is won from solfataras in volcanic regions, but such sources are not generally able to compete on a price basis with the others already mentioned. In the Far East, the main known sources of sulphur are in the volcanic regions of Japan, the Netherlands East Indies, and to a minor extent in the Philippine Islands. Large bodies of pyrite, such as are mined in the Mediterranean region, have not been found nor are there any known major deposits of sulphides of the other minerals such as occur in the United States, Canada, Australia and elsewhere, from which a by-product supply may be expected. In none of the Far Eastern countries except Japan do domestic supplies of sulphur seem to be large enough to support a major transformation of industry, and in Japan the necessary supply would only be available at a material handicap in cost.

In Japan, sulphur is widely distributed, being found in and around the numerous volcanic peaks from Hokkaido to

Taiwan, occurring not only as solfatara deposits but as replacements in tuffs and as sediments in lake beds. It is mined for local use and—though formerly exported—can hardly compete in the world's markets with the more cheaply produced sulphur of the Gulf coast in the United States. In 1924, production from 13 localities amounted to 45,000 tons, the outputs ranging from 300 to 15,000 tons. Not much is known of the possible reserves of sulphur, though in the "Principal Mines of Japan," published by the Mining Bureau of the Department of Agriculture, the leading mines are described. The largest producer is the Kumadomari, where it is locally estimated that 600,000 tons of rock containing 40 percent of sulphur is available. At the Numajiri mine similarly, 1,200,000 tons is estimated of the same grade, but it is proper to say that these estimates are general only and so are received with considerable reserve by American mining engineers familiar with sulphur production who have visited the properties.

In connection with the mining of copper, an important industry in Japan, it is possible to recover sulphuric acid as a by-product and something in that direction has already been done, but such acid will necessarily be used at or near the source of supply, because of its weight and the difficulties involved in shipment. Except as it may displace and thus release for international trade native sulphur, it is only important as contributing to the economic and strategic security of Japan itself. It is clear that the country can supply its own needs, even with considerable expansion in industry, but until American deposits show signs of exhaustion or other major economic conditions change, Japan can not make any large contribution to the world's supply.

In the Netherlands East Indies, Brouwer[1] notes that sulphur is found as incrustations in the neighborhood of solfataric centers, in sulphur mud, and in bedded deposits in crater lakes. There has been some exploitation by natives. At Papandajan, 3,500 kilograms yearly has been won, and at Welirang crater rim deposits contain 51-55 percent sulphur. The Kawah Idjen lake deposits of mixed

[1] Op. cit., 135.

sulphur and silt are considered to be the most important, and are estimated to contain 60,000 metric tons containing 50 percent sulphur. From 1911 to 1913, 2,000 tons of sulphur was mined from the Wurlali volcano on Dammer Island and used for making acid. Veins of the sulphides of iron, copper, lead and zinc are known but are nowhere being exploited for sulphur. Despite the presence of native sulphur in the Islands, Java is a consistent importer of the material so that costs of production would seem unfavorable.

In the Philippine Islands, sulphur is found around old solfataras and has been mined at Silay, Oriental Negros. W. D. Smith[1] has summarized the knowledge of these deposits and lists five districts in which there is an estimated tonnage of 8,000, of which more than half is on Camiguin Island. No deposits of sulphides likely to yield sulphur as a by-product in unusual amounts, are known.

In China, native sulphur has not been found except in insignificant amounts. According to V. K. Ting,[2] "Sulphur is made in Shansi, Honan, Hunan, and Szechuan partly from pyritiferous shale and partly from sulphide ores of lead and zinc." C. Y. Wang[3] states that the sulphur production of China in 1915 amounted to 2,310 tons, equal to one quarter of one percent of the world's output. Except for a small amount derived from the Shui Kou Shan lead and zinc mine, it is derived from native sulphur or from pyrite, the iron sulphide. He mentions the She Shan mine in Shansi, where a bed "6 inches to 5 feet" in thickness lying between the Ordovician limestone and Carboniferous shale, yields 300 tons per year. About 180 tons was mined in 1914 at Kuang Kou in the form of pyrite nodules in a grayish clay resting on Carboniferous sandstone. An estimate of 120,000 tons in reserve is given, but on what basis it rests was not stated. The principal production of native sulphur is in the Taiyuan district of Shansi, and it is from here that sulphur comes for use at the arsenal at Tehchow in Shantung and for use in making fireworks at various centers. The neighborhood of Taiyuan is a hilly country

1 "Geology and Mineral Resources of Philippine Islands," pp. 395-399.
2 Mining Magazine, Vol. XVII, pp. 188-190, 1917.
3 "The Mineral Resources of China," p. 7.

in which bedded sulphur is found, interbedded with sandstones, in part calcareous. While the region is coal-bearing, the sulphur is not found with the coal. The individual sulphur beds are one or two feet thick and are worked by small shallow shafts. The sulphur is refined in pots buried in small coal. Four companies control the production, working under a Government monopoly bureau which has branches in various parts of the country. In 1921, the total output is said to have been about 650 tons. In other parts of the province there is also a small scattered production amounting to two or three tons. These deposits hardly afford much hope for creating a large industry.[1]

H. Y. Liang[2] lists 2,304 tons of sulphur as having been produced at the Shui Kou Shan mine in Hunan in the years 1896-1914, inclusive. In these various figures it is probable that the weight of sulphur ore, pyrite, rather than of the sulphur itself, has been used. It is clear that the amount so far mined is small and that any large supply for the future must be obtained through making sulphuric acid as a by-product in smelting lead, zinc, or copper ores. While many small deposits of sulphides are known, none has yet been found which was of such size as to warrant investment in the complete smelting works that would be necessary for this purpose. At the Shui Kou Shan mine, the largest known body of mixed sulphide ores, a modern lead smelter was for a time operated, but lead ores do not contain sufficient sulphur to make recovery feasible. The mine has been examined several times with a view to determining the possibility of supplying ore for a local zinc smelter to be built along modern lines, but each time with negative results. There is near it a contact orebody of iron pyrite containing a small amount of copper, which, on opening up, may prove important. At the Chow Yen gold mine in Shantung there is also the possibility of recovery of a small amount of iron sulphide as a by-product. Aside from these deposits it seems likely that sulphuric acid works in China will continue to be dependent upon shipments of pyrite mined from small scattered deposits.

1 Far Eastern Review, July, 1926.

2 "The Shui Kou Shan Mine in Hunan, China." Mining and Scientific Press, June 12, 1915.

While China can supply her present needs locally, there are no known deposits that would certainly enable the country to be independent in event of such industrial development as would demand large amounts of sulphuric acid.

CHAPTER VI

NON-FERROUS METALS

IN technical and non-technical literature covering the Far East there are many references to mines of the non-ferrous metals, especially of gold and silver. From the earliest contact of Westerners with the Orient, there has been a general belief in the richness of the East in these metals. The data covering their occurrence and distribution in the various countries have never been adequately assembled and reviewed, though in standard texts such as those of MacLaren [1] and Curle,[2] brief summaries of the obtainable knowledge regarding particular metals have been made available. In other special books, such as "Mineral Enterprise in China," by W. F. Collins,[3] special phases of mining are discussed and incidentally brief descriptions of individual districts are given. Collins was concerned particularly with the difficulties met by various foreign companies that had attempted to conduct operations in China, but he also discussed the history of mining, the nature of the mining rights, legislation, taxation, and similar matters. Many other books covering especial phases might be mentioned, but for none of the non-ferrous metals is there any general summary corresponding in character to the report on the iron ores of China already cited. The amount of data available varies from country to country and, while no attempt will be made here to cite all the literature or to include a complete bibliography, the leading sources will be mentioned for each in turn.

For reasons similar to those already mentioned in discussing the coal and iron deposits, it will be convenient to begin this chapter with what is known and to be inferred

1 "Gold: Its Geological Occurrence and Geographical Distribution," by J. Malcolm MacLaren. London, 1908.
2 "The Gold Mines of the World," by J. H. Curle. London, 1902.
3 Tientsin Press, Ltd. Rev. Ed. 1922, 410 pages.

with regard to these non-ferrous minerals in China. There are four general summaries, none of them complete but all useful, to which reference may be made and which have been freely used in compiling this chapter. These are papers by Bailey Willis,[1] T. T. Read,[2] V. K. Ting,[3] and C. Y. Wang.[4]

W. H. Wong, now Director of the Geological Survey of China, in a paper concerned mainly with the genesis of the ores,[5] has given notes on the occurrence of nearly all the better known occurrences of the non-ferrous minerals and in "The China Year Book for 1925" has contributed a brief but helpful summary of the present condition of the mineral industry. After speaking of coal and iron, he says:[6]

> "As to the other metals it is to be noticed that China is remarkably poor in such common metals as copper, lead, zinc, and especially silver; Chinese production of these metals is almost insignificant in comparison with her immense territory and population. On the other hand, China has become during a comparatively short period, the leading producer of the world for antimony and tungsten. These two metals or their ores are produced in China in such quantity and such low price as no other country in the world can produce. The tin industry of Yunnan . . . is still maintained. The recent development of manganese and bismuth ores seems to be promising."

Numerous additional papers, many of which will be cited in this text, deal with particular deposits or districts but the summaries here mentioned are those that are most complete and widely accessible.

In considering the general distribution of the mineral deposits Willis[7] pointed out that there are in China two separate areas and sets of conditions to be taken into account: (1) North China, where rocks younger than the very old

1 "Mineral Resources of China," Bailey Willis. Economic Geology, Vol. III, pp. 1-36 and 118-133, 1908.

2 "The Mineral Production and Resources of China," Thomas T. Read, Trans. A. I. M. E., Vol. XLII, pp. 1-53, 1912.

3 "Mineral Resources of China," V. K. Ting. Mining Magazine, London, Vol. XVII, pp. 188-190, 1917. Reprinted from "Far Eastern Review," July, 1917.

4 "The Mineral Resources of China," C. Y. Wang, pp. 1-54, Tientsin Press, Ltd., 1922.

5 "Les Provinces Métallogeniques de Chine," Bull. Geol. Surv. China, No. 2. Oct., 1920, pp. 37-59.

6 Year Book, p. 122.

7 Economic Geology, Vol. III, pp. 1-36.

schists have not been greatly metamorphosed, and (2) South China, where young as well as old beds have been invaded by igneous rocks and widely altered. In North China, gold occurs in lodes and placers, and coal is widespread. In South China, gold, tin, copper, and other metals are widely distributed, but while coal fields are numerous they are individually small and relatively unimportant. Willis compares North China with the eastern United States, the Shansi coal fields corresponding to those of Pennsylvania, and the gold fields of Chihli and Shantung to those of the southern Appalachians. South China he considered more like the western United States, the Tsinling mountains of Shensi and perhaps the mountains of Yunnan and the southwest corresponding to the Sierra Nevada and Coast Ranges. In this latter comparison he was slightly in error as regards the mountains of the Yunnan plateau which, while similar in particulars to the Sierra Nevada, are unlike our Coast Ranges.

North China, as he pointed out, is largely a great alluvial plain fringed with bare mountains rising to 5,000 and 10,000 feet. The rocks include pre-Cambrian gneiss, schist, and granite, pre-Cambrian and Cambo-Ordovician limestone and shale; Carboniferous coal-bearing shale and sandstone; Permo-Carboniferous barren red sandstone; Jurassic coal measures; Mesozoic volcanics; and Pleistocene loess and gravel. The gold-bearing rocks belong to the so-called Archean and consist of schist, gneiss, and granite, all being ancient metamorphic rocks such as are found in eastern Ontario and western Quebec, in Canada. The gold occurs in fissures and gash veins of quartz with sulphides of iron, lead, copper, and zinc. The deposits were described in part by earlier writers [1] and the region was surveyed in 1898 by H. C. Hoover [2] and a staff of assistants. They have given rise to modern placers which Hoover and Willis regarded as being probably of considerable value. Siliceous limestones of late pre-Cambrian age occur in Shansi and Chihli, where they are sometimes interbedded with slate and

1 See "Notes on the Progress of Mining in China," Ellis Clark; Trans. A. I. M. E., Vol. XIX, pp. 571-595, 1891.
2 Hoover, H. C., "Metal Mining in the Provinces of Chihli and Shantung, China." Trans. Inst. M. & M., Vol. VIII, pp. 327 *et seq.*, London, 1899-1900.

quartzite. The rocks attain a thickness of 5,000 feet, make up the main mass of the mountain ranges, and are probably the ones in which occur the silver-lead deposits at Jehol, of which a number of descriptions are available.[1] The Cambro-Ordovician is represented by the Sinian, a non-mineral-bearing limestone formation about 4,000 feet thick. At the top is an erosion unconformity and in pot holes in the limestones occur clays which have been used largely for making pottery. The coal measures of the Carboniferous rest on the Sinian, with widespread but now economically unimportant iron ores near the base. The formation is 500 to 700 feet thick and contains much excellent coal, both bituminous and anthracite. Above it are the barren red Permo-Carboniferous sandstones, followed in turn by the Jurassic coal measures. These are important in western Chihli, northern Shansi, and southern Mongolia. Igneous rocks of various types occur in Kiangsu, Shantung, Chihli, and southern Manchuria in areas of Carboniferous to Tertiary sediments. They are partly intrusive and partly extrusive and include granite, porphyry, andesite, rhyolite, basalt, and tuffs. Willis suggests that the Post-Carboniferous granites of northwestern Chihli may be related to precious metal deposits, but it is generally agreed that the volcanics are of no economic significance, though often showing small amounts of copper at the surface.

Between the North China area just described and South China lie the Tsinling mountains, studied by Willis, which extend westward from Honan. The rocks here have been intruded by both the earlier and later intrusives and the region is supposed to be metalliferous, though the actual evidence is weak. He noted the presence of badly-squeezed pyritiferous graphitic beds. Examination by American engineers of numerous copper and gold prospects in this region have resulted uniformly in disappointment.

The middle Yangtze valley, from Chungking to Kiukiang, is an area of mainly unmetamorphosed Paleozoic and younger rocks resting on old schists. The surface rocks

[1] See papers already cited and "Gold and Silver Mining in North China," A. S. Wheler and S. Y. Li; Mining and Scientific Press, pp. 189-195. San Francisco, Feb. 10, 1917. The district was examined for the N. Y. Orient Mines Co. in 1917 by N. L. Wimmler.

are largely limestone and sandstone, with scattered areas of coal measures. The beds have been intruded by rocks of the diorite type and around the latter are contact deposits of which the only ones known to be important are the iron ores already described. In some places, as at Tayeh, copper and other metals occur with the iron in the form of sulphides, and the Tung Kuan Shan mine was originally worked for copper, but has long been unimportant as a source of that metal. The pre-Cambrian granites, gneisses, and schists come to the surface in the low hill country north of Hankow, near Ichang, and probably elsewhere. Aplite dikes have been described northeast of Hankow.

West of the middle Yangtze region and south of the Tsinling mountains is the red basin of Szechuan. This is about 100 miles in diameter and lies at an altitude of 1,500 to 3,000 feet. To the north and east are mountains of old Paleozoic rocks, rising 8,000 to 12,000 feet high, while to the west is the edge of the great Tibetan plateau, rising to 20,000 and 25,000 feet. On the south are the plateaus of Yunnan and the plexus of mountains which occupy Kweichow. The Szechuan basin proper is underlain by Permian, Triassic, and Jurassic beds, mainly sandstone and coal measures. These have been little disturbed and only locally intruded. The resources of this area include coal, salt, and perhaps petroleum. To the west and southwest, extending into Yunnan, are great areas of intrusives and young igneous rocks. The region is reputed to be heavily mineralized but there is little exact evidence on that point.[1]

South China proper includes a great belt of hilly country extending parallel to the coast from Shanghai southwest to the boundaries of China, forming a bowed-up and dissected peneplain similar in many particulars to the southern Appalachian region of the United States. It is a region of marked relief, but not of great altitudes. In the east the valleys are wide. In the southwest, especially in Western Yunnan, the rivers flow in deep precipitous canyons. Throughout the region there are areas of intrusive rocks

[1] For a general description see "An Engineer's Travels in Western China," J. A. T. Robertson, Mining Magazine, Vol. XV, pp. 267-279. London, 1916.

including granite, quartz-porphyry, and rhyolites. Richthofen considered the region to represent the geological extension of Japan, and others have seen in the granite a northern continuation of the rocks that dominate the Malay Peninsula. Gold, tin, copper, lead, zinc, antimony, and mercury all occur, the antimony, tin, and mercury being more important in the southwest. The gold deposits worked in Chekiang, Fukien, and elsewhere to the east are not impressive and the placers are of doubtful importance. In Yunnan, where north-south trending folds of probably Miocene age have been superimposed upon the older structure, there are quartz veins and replacement deposits that were formerly worked and which attracted attention though those which have as yet been reopened have proved unimportant. Farther southwest in Burma is the great Bawdwin silver-lead-zinc deposit long worked by the Chinese, and now operated by a British company.

W. H. Wong[1] considers that there are in China three distinct metallogenetic provinces. In Shantung, Chihli, and to the north, is an area of the older, pre-Cambrian rocks, characterized by quartz veins in schists and gneisses which contain copper, lead, and zinc in subordinate amounts with gold and silver. The veins are generally small and are rarely continuous to any considerable extent either along the strike or in depth. In the Yangtze valley and central China, extending up into Shantung, is a great area in which are found numerous intrusions of dioritic rocks. Around the edges of those intrusions are found iron ores, already discussed, and with these are subordinate amounts of copper, lead, and zinc. In south China, from Hunan in the north to Yunnan in the south, and from Fukien west to Tibet, is a third region which he finds characterized by the intrusion of rocks of the granitic type and in which veins are found of all the non-ferrous minerals from tin to mercury.

Gold:—The gold deposits were divided by Ting[2] into 4 classes: (1) recent alluvium; (2) ancient alluvium; (3) Tertiary sandstone; (4) quartz veins in Pre-Cambrian

1 Bull. Geol. Surv. China, No. 2, 1920.
2 Op. cit., Mining Magazine, Vol. XVII; Far Eastern Review, 1917.

gneiss and metamorphic rocks. The first is in his judgment by far the most important, as all the productive mines of Manchuria and outer Mongolia belong to this class. The four great rivers in Manchuria—the Amur, the Yalu, the Tumen and the Liao-ho, drain large areas covered by gneiss and granite whence the gold has been washed down together with other products of erosion into the tributary valleys. The gold mines in Heilungkiang province are situated on the right bank of the Amur river, those of Kirin along the tributaries of the Yalu and the Tumen, and the mines of Mukden in the basin of Liao-ho. In outer Mongolia, they are in the valleys of the Iro, the Shara, and the Kurduri, all of which are tributaries of the Selenga that flows into Lake Baikal.

The gold placers, especially of Mongolia and Manchuria, have attracted serious attention and are known to have yielded several million dollars. The history of mining in these two provinces has been summarized by W. F. Collins [1] who has also given the essential facts as to the occurrence and distribution of the gold. The latter is found in the outwash from the great dominantly granite ranges of mountains which form the northern boundary of Mongolia and cross Manchuria. Quartz veins containing gold are known but have not been extensively worked, save by the Mongolor company north of Urga. According to Collins, 40,000 tons was here treated between 1915-1919 and yielded 18,000 ounces of gold of a value of $342,000. The main interest, however, centers in the placers. The most ambitious and successful attempt to work these has been that of the Mongolor, a Chinese-Mongolian-Russian company, based upon a concession granted Baron von Grot in 1899. It covered an area of 263,000 square miles, within which a considerable acreage of valuable placer ground has already been opened. At first, American technical assistance was employed but—the results not being satisfactory—Von Grot went to Nome and worked as a miner to study methods. He returned and reorganized the business so effectively that despite the isolation of the mines and the inherent difficulties to be overcome, it was for a number of years

1 Op. cit., Chapt. X, pp. 134-150, 1922.

highly successful. It is credited with a yield of gold to the value of $6,000,000 in the years 1901-1919, and in 1910-1911, of $1,140,000 per year. In 1914, the yield is stated to have been at the rate of $1,306,000 [1] per year, and the profits about $175,000. Since then political difficulties and changes in control have interrupted operations and less gold has been sent out, though some mining has been done each year. The property has been studied by a number of American and other mining engineers and, while the ground is shallow, there seems to be no doubt that important areas remain to be worked. Farther west, along the south flanks of the Altai mountains there are old native placer workings, as there were on the north; and, while the region has never been adequately studied, it is entirely possible that there will be found here great orebodies comparable to those in the Ridder and other mines on the opposite side of the mountains in Siberia.

Toward the east, and in Northern Manchuria, there is even more abundant evidence of the existence of important placer areas. The region has been visited by various native and foreign engineers, but being chronically bandit-infested, all attempts to explore it systematically have so far come to nothing. The region immediately to the north in Siberia has been explored and described fully. C. W. Purington, a widely experienced placer engineer, has written of it,[2] and it can merely be said that if order can be preserved in the region there is every reason to anticipate that important placer gold mines may be opened and a distinct possibility that areas comparable to those worked in the Klondike and Fairbanks district will be found.

Gold placers have also been found in many other parts of China, but as to them the report that must be made is less encouraging. C. Y. Wang [3] lists a number of localities in Chihli, Hunan, Shantung, Kiangsi, Honan, Kansu, Szechuan, and Hupeh and, in fact, gold has probably been mined from the streams of every province. Many of these placers have been examined by competent engineers and

1 "Gold Mining in Mongolia," Mining and Scientific Press, pp 410-411. San Francisco, Sept. 12, 1914.
2 "Northern Manchuria," Mining Magazine, Vol. IV, pp. 53-58, 1911.
3 Op. cit., pp. 36-37.

there is substantially unanimous opinion that they are, with a few possible and doubtful exceptions along the Upper Yangtze, unimportant. E. C. Thurston[1] studied a number of the placers in 1903 and found that they were much too poor to warrant working, save as an avocation. In Hupeh on the Han river, he found that a gang of seven men earned from 4 to 7 cents a day per man, allowing one extra share for the foreman. Occasionally, the returns ran to the high mark of $2 a day. At another point, assuming the gold to be worth 20 percent more than the miners received, an assumption well within the probabilities, he found that a gang produced 40 cents to $1.36 a day and that the gravel was worth 1 to 4 cents a cubic yard. For comparison it may be stated that modern expensively-built bucket dredges do not make a profit, save under exceptionally favorable conditions, on much less than 25 cents a cubic yard. Thurston concludes his account of these workings as follows:

> "From the examples of placer-mining described, it will be seen that the Chinese are keen prospectors, industrious workers, and are satisfied to earn a pittance. Gold is widely distributed throughout China, but probably in no readily accessible district in sufficient quantity and sufficiently concentrated to warrant foreign exploitation. The evidence seen during the trip in 1903 led to a conclusion precisely similar to that of von Richthofen, who traveled extensively through China and whose opinion was reported to the Shanghai Chamber of Commerce in 1872."

He then quotes von Richthofen as below:

> " 'From my own experience on the subject I have arrived at the conviction that the great number of places in which gold is washed from river sand in China at the present day, far from furnishing a proof of the wealth of the country, is, on the contrary, clear evidence of the superabundance of human labor, the general prevalence of relatively low wages, and the poverty, individually, of those engaged in the search for gold. The gold washers of to-day, with probably very few local exceptions,

[1] "Gold Placers in Central China," Mining and Scientific Press, pp. 270-273; San Francisco, 1913.

earn less than the lowest wages which they can get for ordinary labor, and take to their occupation in those seasons only when there is the least demand for field work. We can, therefore, safely conclude (with those few exceptions) that the greater the yield in gold, the greater will be the poverty of any one province. The sum total is, in some of the overpopulated districts, not inconsiderable, and has quite misled the judgment of those who have even witnessed the miserable conditions of the gold diggers. The number of places in which gold occurs in the various hilly countries of Europe is probably greater, on an average, than an equal area of China. But no notice is taken of them because nobody could be induced there to wash gold for so little return as is generally obtained in China.' "

Similar alluvium is found along the Upper Yangtze between Yunnan and Szechuan, the southern tributaries of the Tarim in Turkestan, and the smaller streams in Shantung. There are persistent but unverified rumors of rich placers on the Upper Yangtze. In Tibet, gold occurs widely distributed in placers and has been mined irregularly for centuries. Collins [1] and Maclaren [2] each summarize what is known of the mines of the district as well as the political conditions. It can only be said that evidence that deposits of mineral of any character are especially large or rich rests on uncertain and secondary data, and that both natural and political conditions are distinctly unfavorable to mining. If in the future Tibet be found to contain mineral resources of importance, they seem more likely to consist of gold and other metals of value by the ounce than of coal, iron and others that run into large tonnage.

The second class of deposits mentioned by Ting, ancient alluvium, occurs at a few points, notably the Wali gold mine on the Yalung river in Szechuan. No satisfactory description of this property is available and on the basis of the data at hand it is impossible to make any valuable estimate of its importance. The same situation obtains as regards the third class of deposits mentioned, a certain Tertiary sandstone known as the Hanhai formation and having a wide distribution in Turkestan and Kansu. In

1 Op. cit., pp. 150-156.
2 Op. cit., pp. 228-237.

localities given by Ting as Kwenlun and Nanshan, it is said to be frequently auriferous. How important it may ultimately prove to be cannot at present be estimated.

Vein deposits containing gold in quartz or with sulphides in connection with various gangue minerals are widespread especially in the North, but are nowhere worked in a large way. C. Y. Wang lists a number of occurrences and Read [1] notes even more and also gives an extensive list of references to such descriptions as have been printed. He concludes with the statement "that with the exception of Manchuria and the southwestern provinces of China (Yunnan and Szechuan) the gold-mining industry gives little promise of growth." It may now be added that such exploration in western Yunnan as was carried out by the engineers of the New York Orient Mines Co., gave discouraging results as to the finding of large deposits of gold ore unless in the most remote and inaccessible parts of the province. Such results, while not conclusive, may fairly be considered indicative.

Szechuan has been visted by a number of engineers but carefully studied by none. Rich ore-shoots have been reported, especially in the Maha mine.[2] This and other properties have been mentioned by numerous travelers and a considerable international controversy has raged at times over mining rights in the province. At present, it can only be stated that, while what is known of the geology of the region is favorable to the occurrence of gold and the metals usually associated with it, especially in the western part of the province, much of the evidence of their actual presence in quantity is similar in character to that which in other parts of China has proved distinctly disappointing when checked in the field.

In Chihli and Shantung are veins containing gold and silver concerning which more definite data are available.[3] A number of them have been worked at various times under direction of foreign engineers, and modern milling and pumping machinery has to some extent been introduced.

1 Trans. A. I. M. E., XLIII, pp. 39-42.
2 "The Minerals of Szechuan, China," Herbert W. L. Way; Mining Magazine, Vol. XV, pp. 20-23, 1916.
3 See W. H. Wong, op. cit., pp. 52-57.

The various districts have been described by Ellis Clark, H. C. Hoover and A. S. Wheler in papers already cited, and the principal mines were restudied by N. L. Wimmler, Fred Searles and George Scarfe for the New York Orient Mines Co. in 1916 and 1917. Hoover and his staff examined more than 50 mines in these two provinces and found but a few of any probable value. The veins in the Jehol district proper are valuable mainly for lead and silver and will be discussed later.[1]

Hoover found all the metalliferous deposits of the region to be confined to the ancient rocks and considered that they were not related to the fairly abundant recent volcanics. He discriminated two classes of veins: (a) gash veins which are unimportant though numerous, and (b) normal fissure veins of possible value. Of the latter both narrow and wide examples were found. He described at Chang-kow-liang a vein 12 to 24 inches wide which had been stoped a distance of nearly 1,000 feet along the strike in each of two ore-shoots. It contained 10 percent of sulphides from which 43,000 ounces of gold had been won in 39,000 tons of ore mined in six years, in part below water-level. This was the most important of the narrow veins seen by his parties. As an example of a wide one he referred to the well known Chao-yuen mine in Shantung. This, and other properties in the two provinces were described by Ellis Clark, and the Chao-yuen has been mentioned by many others. Several veins of considerable size have been mined in the region south of Chefoo, the three most important localities being Ming-lai, Ping-tu and Chao-yuen. At each, modern machinery has been used to some extent. The ore is in quartz veins of not exceptional size in older rocks but, as usual, the ore-shoots are less extensive though still notable. At Ninghai, the average of all Clark's samples[2] ran $1.87 per ton. Samples from the large deposit ran from 77 cents to $5.85 and selected quartz contained $24.75. At Ping-tu, he found the vein to vary from 4 to 10 feet in thickness and a sample taken as an average from a pile of 1,500 tons of concentrate assayed, gold $36.31;

1 The principal mining localities in North Chihli are shown in Fig. 7.
2 Op. cit., p. 579.

silver, \$2.94. As the ratio of concentration is not given the value of the crude ore cannot be figured. The Chao-yuen district contains a number of quartz veins, some reported to be 50 to 75 feet wide, in which ore-shoots are present. Clark gave the average of 19 ore samples taken from prospect holes in the district as \$5.86 and of 10 samples \$9.75 in gold. J. H. Curle reported that at one time there was a reserve of about 200,000 tons of ore worth \$10 per ton.[1] Since then the mine has been worked irregularly and unsystematically, and when visited in 1917 no important reserves were to be found. The district is, however, one from which under stable political conditions, and assuming that proper business and technical administration be available, a moderate yield of gold may be expected for a number of years. So far as definite data are at hand, the Chao-Yuen are the most important gold mines in China.

The ancient crystalline rocks found in Chihli and Shantung underlie Manchuria and extend down the Korean peninsula. In both areas gold, and subordinate amounts of copper, lead and other metals have been mined. As to Manchuria, the following statement has been made by the Geological Survey of Japan:[2]

> "Gold is often contained in quartz veins, traversing gneiss, quartzite, clay, slate, granite or contact zone of gneiss and granite, etc.; but these veins are generally thin and barren of gold. The greater part or almost all the gold is washed from sands or pebbles of Quaternary deposits, as placers. Though localities of placer gold are abundantly known yet they are scarcely worth mentioning here."

In Korea, gold-mining has been an extensive and profitable industry. Maclaren has given a brief note on the mines with citation to more complete descriptions, and in the files of the British and American mining journals will be found full accounts especially of the mines of the Oriental Consolidated and the Collbran-Bostwick Syndicate, both of which have been successful and profitable. The number of opportunities for such enterprises seems to be limited, since

1 "Gold Mines of the World," p. 216.
2 Bulletin of the Imperial Geological Survey of Japan, Vol. XVIII, No. 2, Tokyo, 1905, p. 11.

ventures undertaken by other companies at the same time have proved disappointing.

Exact records of the gold output of China in recent years are not obtainable. In 1915, Ting estimated the total at 200,000 ounces, of which 120,000 came from Manchuria and 60,000 from Mongolia. The disorder in these northern countries has since cut down the production from the placers and the American Bureau of Metal Statistics credited China with a probable 100,000 ounces, worth approximately $2,000,000, in 1925.

Silver:—This metal is usually associated with zinc and lead in China as elsewhere, but some of the silver comes from the gold quartz veins just discussed. Geologically, they are of two classes of veins: (1) those in Archean gneiss; (2) in Paleozoic limestone. The former class is chiefly found in north Chihli and north Shansi and the sulphides present are usually small in amount, but rich in silver. The second class of veins is much more widespread but the silver content is somewhat smaller, averaging, according to Ting, perhaps 16 ounces. Probably the best known silver mines are those of the Jehol district in Chihli. Wheler describes the silver as occurring there mainly as argentiferous galena in quartz veins in granite or as a series of small intralacing veinlets known as a "stock work" though part of the ore replaces the limestone. In 1917, the district was producing about 30,000 ounces a year. Earlier, the output had been much higher. Hoover had the following to say as to silver in the area he studied:

> "No silver deposits of any consequence have been found in Shan-tung, but some mines have been worked to a considerable extent in Chi-li, particularly near Ch'öng-tö (Je-hol). The principal mines have been worked by foreign methods, and consist of a series of quartz veins in limestone. These veins carry throughout well-distributed argentiferous galena in small quantities, but more particularly lenticular masses or seams up to one foot wide and 100 to 200 feet long of almost solid galena, yielding up to 500 ounces of silver to the ton. Silver occurs native, as sulphide, chloride, and as ruby silver, and is associated with the sulphides of lead, zinc, arsenic, and antimony. There is no gold traceable.

"The rich orebodies are very erratic, and failure resulted from the installation of foreign methods, although the natives, by continuing the use of pumps, are working 850 feet deep at Ku Shan Tzu. Other small silver-lead veins were observed associated with felsite dykes, but were also very narrow." [1]

Outside the Jehol district the silver output is strictly subordinate to that of other metals, lead, zinc, and copper in connection with which it is found occasionally. In 1920, samples of the copper being made at Tungchuan and of the zinc and lead smelted at Hungshan, two of the leading mines in Yunnan, were carefully assayed for gold and silver without result. In the far western part of Yunnan, silver was formerly won from lead-silver deposits. It is possible that there remain deposits of importance, though those tested in 1919-1920 proved disappointing.

Lead and Zinc:—While both of these metals are found at many localities in China [2] the amount of either produced is small and has long been so. It is estimated that the current production of lead is 2,000 tons per year, though in recent years the amount has been as much as 5,000 to 6,000 tons. The present output of zinc is of the order of 8,000 to 10,000 tons, but during the war and immediately after as much as 30,000 tons was credited to the country. There are two mines that have been worked primarily for lead and zinc; at the others the production has been mainly for gold or silver with lead as a by-product. In Hunan, southwest of Changsha, the Shiu Kou Shan has been operated by modern methods and, with moderate contributions from neighboring properties, has been mainly responsible in recent years for the Chinese output of zinc and lead. A number of descriptions of the property have been published [3] and the mine has been examined by a number of foreign engineers. It is under the control of the Hunan Mining Board. The orebody occurs at the contact of an intrusive rock of the granitic type, with limestones probably of Carboniferous age.[4] It has been opened to a depth of over

1 Op. cit., p. 329.
2 Wong, W. H., "Les Provinces Métallogenique de Chine."
3 See especially, "The Shiu Kou Shan Mine in Hunan, China," by H. Y. Liang; Mining and Scientific Press, June 12, 1915.
4 Wong, W. H., op. cit., p. 42.

800 feet on the vein and several ore-shoots of mixed sulphides are known. One of these is 45 to 60 feet wide and 600 to 900 feet long, according to Liang. The analysis of the ores as they come from the shafts are given by him as below:

	Pb. %	*Zn. %*	*Ag. oz.*
No. 1 Shaft	33.90	29.40	21.2
No. 2 Shaft	19.10	29.40	18.0
No. 3 Shaft	23.40	23.70	18.0

The ore is dressed in a modern concentrating-mill and the zinc concentrates shipped abroad. The lead was for a while smelted in a modern furnace but in recent years the work has been interrupted. Prior to 1896, the mine was operated by native methods and old workings extend to a depth of 600 feet. Between that date and 1916, according to Wong, there was a total of 70,000 tons of lead ore and 184,000 tons of zinc ore produced from this property.

The second most important production of lead and zinc in China comes from the Kungshan mines in Yunnan. These are in the northeastern part of the province and were visited in 1920. The ore occurs as a carbonate in limestones of Permo-Carboniferous or Triassic age. The veins are small, though numerous, and no extensive replacement bodies were to be seen. Native workings extend to a depth of 800 feet and in a number that were examined in 1920 there were no evidences of large ore-shoots, though the veins seem persistent. Both lead and zinc are reduced in local furnaces operated by native methods, and a limited amount of metal has been marketed through Yunnan-fu. The distance and the cost of transport by pack-train effectually shut it out of the general market, and the small size of the orebodies and high cost of mining render it inadvisable to attempt introduction of modern means of mining and transport for the mines alone. While silver has been reported from these mines, assays of the lead and zinc being produced in 1920 failed to show it to be present.

In Western Yunnan there are found at several points ancient workings and extensive bodies of old slags such as first attracted attention to the Bawdwin deposits in Burma. The geology of the deposits is, however, different and the

slags do not show the high content of lead that gave initial value to those at Bawdwin. Diamond-drilling and a moderate amount of underground exploration in one such district north of Tengyueh, led to the conclusion that the unworked portions of the orebodies remaining were too small and of too low grade to warrant provision of modern facilities and transport. Other similar slag bodies are known farther south and, while they are in a particularly inaccessible district, it is possible they may ultimately prove of importance.

In general, in various provinces of China both lead and zinc occur in small veins suitable to mining by native methods on a small scale, but not affording an adequate basis for employment of large capital. In the aggregate they may be made to yield a moderate amount of lead and zinc for local use, but there is no evidence available indicating that the supply is adequate to any extensive industrial development or will afford the basis for a large export trade.

Copper:—According to V. K. Ting, the occurrences of copper ore in China are extremely numerous but few have proved of value. Genetically he classifies deposits into five groups: (1) magmatic segregations; (2) contact deposits; (3) replacement and fissure veins; (4) impregnations; (5) sedimentary deposits of the well known "Red Bed" type.[1]

Examples of the first group may be well seen in the Permian basalt of Yunnan, which covers immense areas. Throughout the northern part of this province, wherever this rock crops out, there are abandoned mines and heaps of slag. These gave the French engineers erroneous impressions of the mining possibilities along the Yunnan-Tonkin railway, but Leclère, who reëxamined the region in 1897 estimated their importance correctly.[2] They are practically without exception small, irregular bodies entirely unsuitable for modern working. Similar occurrences are known in the Tertiary porphyries of northern Chihli.

1 For map showing location of principal copper districts of the Far East, see Fig. 8.
2 Ann. des Mines, 9 Ser., Vol. 20, Mem. 1901, pp. 367-384, 441-443.

The second group, contact deposits, is associated with the iron ore in the central region, being due to the contact action of the diorites. Such deposits are found scattered in southern Hupeh in the districts of Shingkuo and Yangshing. The Tayeh iron deposits, already described, have copper sulphide associated with them and, as already noted, the Tung Kwan Shan deposit was first worked as a copper mine. The deposits are generally of no economic value, but near the Shiu Kou Shan mine Searles examined one such that has possible value. The government mine at Pangshih in Kirin, Manchuria, seems to belong to this type; the copper content of the ore worked is usually above 10 percent, though the reserve is limited. Mining stopped here in 1918 and has not been resumed.

The third class, replacement and fissure vein deposits, is by far the most important and there are many examples. The copper mines around Tung-chuan in Yunnan, the ones yielding the largest amount of copper in China, are of this character. In the limestone the veins form stock-works with minor amounts of replacement. In shale the veins are narrower and there is little replacement. Similar deposits are to be found in Hueili district in the southern part of Szechuan.

The Tungchuan deposits have long attracted attention and copper has been mined there for hundreds of years. In the seventeenth century the mines were placed under an Imperial mining board and Leclère states that at the end of that century the output was about 6,000 tons a year. The mines are now controlled by the Yunnan government, and the production is given of the order of 800 to 1,000 tons a year. The copper comes from a number of localities one to three days' journey from Tungchuan, the chief city of the district, where it is assembled, refined and in part made into brass by mixture with zinc from Kungshan about two days' journey to the east. The mining is done by native methods and the ore is closely sorted by hand in order to secure material for first reduction by small native furnaces fired with roots and stumps, the trees having long since been cut off. At Tungchuan, reverberatory furnaces have been built and with coal, also brought mainly from Kungshan.

the crude metal is refined. It does not contain either gold or silver in important amounts.

The mines have been visited by several foreign engineers. R. M. Raymond, now Professor of Mining at Columbia University, examined them in 1901 for the Anglo-French syndicate at that time active in Yunnan. Collins, the later representative of the same group, states that "he reported that these mines were too nearly exhausted to furnish even a moderate supply of ore. He was of the opinon that the mines were not paying under the existing complicated system of Chinese official control, that the deposits were not large enough to make a good mine; also that he could not see any prospect of profitable orebodies at greater depth." [1] In 1920, in company with M. D. Draper and C. K. Li, I reëxamined the deposits for the Yunnan government. The ore was found in part in the basalt and in schists but came mainly from stock-works and zones in limestone. The rock was fissured and broken by a multitude of small cracks in which, near the surface, copper carbonate was found and at depth sulphides, mainly chalcopyrite and bornite. The individual fissures had been followed downward several hundred feet by narrow tortuous workings from which small amounts of carefully hand-picked ore was won. The largest body of ore seen was in limestone where a rough estimate indicated the probable original presence of perhaps 1 percent copper through a million or more tons well situated for open-pit mining. The bulk of the copper had, however, been already picked out of this deposit. In general, by marketing the copper as the company did, partly in brass cash and partly in copper sheets and copper ware, it was then realizing a price per pound substantially double the contemporary price in New York. This was possible only to the extent that it could sell copper within the region where the local mines had a natural monopoly because of the distance from the railway and cost of transport.

The fourth type, impregnation, is exclusively found in pre-Cambrian crystalline rocks of south Shansi, and northwest Hupeh. The deposits are usually of low grade, but the reserve sometimes reaches respectable dimensions. One

1 "Mineral Enterprise in China," pp. 60-61.

orebody, containing possibly 1,000,000 tons and having a probable average grade of 1 percent, has been reported, though it has never been completely sampled. The government mine of Pengshien near Chengtu (Szechuan) belongs to this group. The mine has been given modern equipment but owing to political conditions production has been declining. W. H. Wong, in the China Year Book for 1925, gives 5 tons as the output in 1923. The orebodies are large lenses in the crystalline schists and limestone, the average copper content being reported to be about 5 percent. Up to the present, no adequate data have been brought to light to warrant the conclusion that copper deposits of first rank are to be expected.

The occurrence of copper in the "Red Beds" in China is of great geological interest but not of economic significance. In Yunnan and Kweichow, the lower Triassic sandstone overlying the Permo-Triassic coal measures contains copper, usually in the form of malachite, which used to be worked in the district of Hsuanhui, Yunnan. Similar deposits are found in the Hanhai formation in Turkestan; for example, the copper mines near Aksu. Where these deposits were seen in Yunnan in 1920, they were found to be of the usual "Red Beds" type found in many parts of the world and the amount of copper present was so small that it having been worked at all was an evidence rather of the general poverty of the region than of the richness of the deposit.

The present production of copper in China is about 2,000 tons, mostly from Yunnan, Kirin, Kansu, and Turkestan, the first province supplying about 50 percent.

Tin:—Tin is at present the most important metal produced in China from the point of view of value. The country ranks fourth among the world's producers and can be counted upon for 8,000 to 10,000 long tons a year. In 1916, the output was 8,600 tons which rose to 14,000 in 1922, after which it dropped to a low point estimated[1] at 7,000 tons in 1924, since when there has been a recovery to 8,500 or more. Over 80 percent of the tin comes from

1 Amer. Bureau of Metal Statistics.

the Kotchiu district near Mengtze in Yunnan. The remainder is from a number of small districts following a belt from Southern Hunan through Kwangtung and Kwangsi into Indo-China. In southern Hunan, at the Kingwha mines the tin is alluvial [1] as also across the border at Fuchuan in Kwangsi.[2] In both districts the geology is such as to leave little doubt that the original source is in veins or pipes in the limestone, associated with a granite intrusive that underlies the belt. In the Linhsien and Linhwa districts the ore is definitely ascribed to such veins or pipes [3] and in a general résumé of the district W. H. Wong [4] treats the region as a typical tin-tungsten belt related to the granite. While the vein tin is associated with fluorite and minor amounts of various sulphides, the alluvial tin is remarkably pure and is in demand at Hongkong for diluting the less pure metal from Kotchiu. The output of these mines has never been large and the information available does not indicate that they are of first rank.

The extension of this belt into Indo-China now yields [5] about 300 tons of metallic tin per year, the ore coming from Kao Bang and being smelted locally. The Nam Palen mines in the Laotin basin are also locally important. The Laos districts indeed are attracting attention and do offer possibilities though the geology is not known in detail. A large deposit is reported at Bo Neng.

The most important tin-producing district in China is at Kotchiu near Mengtze in southeastern Yunnan. It was for many years distinctly inaccessible because of anti-foreign sentiment among the local miners and smelters. It was visited, however, by a few French, British, and American engineers and in 1920 was examined for the Yunnan government by myself and party. Since then, M. D. Draper, then associated with me, has been chief engineer for the principal company, the Kotchiu Tin Trading Co., which is controlled by the Provincial government. The district produces 7,000

1 "Visiting the Hunan Tinfields," Gilmour E. Brown, Mining Magazine, Vol. XIII, pp. 141-145, Sept., 1915.

2 "Tin and Coal Deposits of the FuChuan District, China," M. B. Yung. Trans. A. I. M. E., Vol. L, pp. 689-697, 1914.

3 C. Y. Wang, op. cit., p. 26.

4 "Les Provinces Métallogeniques de Chine," pp. 39-41.

5 J. W. Furness, "Tin in 1925." Min. Res. U. S., 1925, Pt. I, p. 84, U. S. Bureau of Mines, Wash., 1926.

to 9,000 tons of metallic tin per year. The supply comes from lodes in limestone. The mountains on which the mines are situated stand 4,000 to 5,000 feet above the plains, so the water level is far below the summit and the veins have been deeply oxidized. This accounts for the impression which obtained, before underground studies were made, that the ore was entirely placer. It is in fact residual essentially in place. In the mountains there is an important intrusive granite and the veins are of the usual tin-tungsten type, though tungsten is subordinate and has never been produced in quantity. The mineralized area is large, the veins well defined, the ore-shoots persistent, and it is to be expected that production from this district will become more rather than less important. A narrow gauge railway connects it with the main line of the Haiphong-Yunnan-fu railway and a modern mill and smelter were some years since built. The principal mine is now about to be opened by a vertical shaft superseding the slope up which ore has long been carried on men's backs. The workings extend to a depth of 1,500 feet.

Tungsten:—One of the few minerals of which China contributes an important percentage of the world's output is tungsten. In 1924, 63 percent of the total came from this country. Tungsten had no value to the ancients, so that the abundant ores found in the residual soil over the veins in which it occurs were not mined away. It was only at the period of world shortage during the War, that attention was attracted to the Chinese deposits. A little came out in the first year of the War and production rose in two years to an output estimated by F. L. Hess at 10,000 tons of concentrate.

Occurring as the material does at the surface and being readily amenable to wet concentration with a simple plant, the mining of tungsten ore fits in particularly with Chinese methods and within a short period the shipments were large enough first to dominate and then to break the market. At the present time high percentage concentrates can be laid down in New York or European ports cheaper than from any other district. While much of the richer, easier to be

won material has now been marketed, large quantities presumably remain, and for a considerable period China may be expected to rank first among producers.

Though minor amounts of tungsten ore have been found elsewhere, the important deposits are in the southeast. W. H. Wong recognizes two tin-tungsten belts,[1] one near the coast and extending down through Fukien; the other, and more important, extends along the border line between Kiangsi and Hunan on the north and Kwangtung and Kwangsi on the south, running on into Indo-China. It is the same belt in which the tin deposits, already mentioned, are found, and the mode of occurrence is the same, tin and tungsten coming often from the same veins. He quotes C. Y. Hsieh[2] to the effect that the principal center of tungsten production is at Yao Kang Hsien in Hunan, where a mass of granite is intruded between limestone and quartzite. There are many quartz-tungsten veins in the quartzite but not in the limestone. Toward the east, tin replaces tungsten. C. Y. Wang[3] lists a number of individual localities. The extensive area is far from completely prospected and vein mining has hardly been begun. It may be expected, therefore, that China will be able to supply tungsten in important quantities for a long period though not, probably, at the low price of recent years. The deposits and working methods have been described recently by C. F. Creveling[4] and have been discussed by F. L. Hess[5] who has kept in close touch with their development. The total output in 1924 was estimated by Colin G. Fink at 3,500 metric tons coming mainly from Kiangsi.[6]

Outside the region described, while tungsten is known to occur, as at Kotchiu in Yunnan and in northern Chihli, there is no indication of large deposits being present.

Antimony:—In antimony, China dominates the world's market and seems likely to continue to do so for an indefinite period. According to J. W. Furness:[7]

1 "Les Provinces Métallogeniques de Chine."
2 *Ibid.*, p. 40.
3 Op. cit., p. 31.
4 Iron Trade Review, April 24, 1924.
5 Eng. Min. Journ.-Press, Jan. 17, 1925.
6 The Mineral Industry, Vol. XXXVIII, p. 718.
7 Mineral Resources, 1925, Pt. I, U. S. Bureau of Mines, 1926.

> "China's production of antimony is not accurately known and the statistical information available is based on the exports. During the period 1908 to 1916, slightly more than 50 percent of the world's production was furnished by China; from 1917 to 1920, 60 percent; from 1921 to 1923, 80 percent; and during the last two years, 90 percent. The price at which Chinese antimony is sold is partly related to the rate of exchange and therefore fluctuates with the value of silver."

He gives the following table showing the output and value of the mines:

EXPORTS OF ANTIMONY FROM CHINA

(*With quotations at New York*)

	Exchange rate Hong-kong (taels)	*Exports (Metric tons)* 1	*New York price C.i.f., cents per pound*
1912	0.74	13,531	7.76
1913	.73	13,032	7.42
1914	.67	19,645	8.53
1915	.62	23,357	29.52
1916	.79	42,800	25.33
1917	1.03	28,450	20.73
1918	1.39	7,721	12.55
1919	1.26	15,597	8.16
1920	1.24	13,001	8.32
1921	.76	14,658	4.92
1922	.83	13,858	5.42
1923	.7975	14,256	7.81
1924	.78	12,059	10.77
1925	.7577	18,928	17.50

More than 90 percent of the antimony mined in China comes from Hunan, where it is widely distributed. The most important centers are in the valley of Tzukiang in the districts of Shinghua, Anhwei, Yiyang and Paoching. The mineral is usually stibnite, but the oxide occurs also in small quantities. The best known deposit is that of Hsikungshan, where the ore beds occur between the quartzite and the upper limestone which are either lower Carboniferous or upper Devonian. These beds are folded into anticlines and domes, with which the ore seems to have a constant relation. Most of the other Hunan deposits are found in the same horizon, but in Yunnan the Amichow deposit is probably in the Triassic formation. The antimony deposits

1 Maritime Customs, Foreign Trade of China.

have been described in part by H. Y. Liang,[1] A. S. Wheler,[2] C. Y. Wang,[3] and others, and the Geological Survey of China has published a description of the most important mines, those near Hsikung-shan in central Hunan, by F. R. Tegengren.[4] He found the antimony to occur here as stibnite in a 150-foot bed of quartzite at the base of a sedimentary series some 1,500 feet thick. He considered the age to range probably from Silurian to Carboniferous. Aside from secondary antimony minerals the stibnite is remarkably pure and is found with quartz as the only gangue mineral. The bed of quartzite in which it is found is to be seen only in the crests of anticlines exposed by erosion. In these crests the quartzite has been fractured and brecciated and the stibnite fills in the fractures and occurs lining caves and open spaces. Tegengren estimated that up to 1915, some 104,000 tons of metallic antimony had been won from these particular deposits. Calculating back from this to the amount of ore mined and that left behind, he arrived at 6 percent as the original average content of the quartzite in the main deposit. Two additional ones, the Chi-li-kiang and Kiang-chung, are considered to be poorer though the latter, especially, is not well known. Aside from the deposits of this district, antimony is known only in ordinary veins which are much less important.

Tegengren made tentative estimates of the reserves of the district and arrived at a figure of 3,000,000 of ore of 55 percent grade as the original content of the Hsi-kwang-shan ridge, of which 1,300,000 tons of metal was estimated as remaining to be won. To this he suggested the addition of 3,000,000 tons of ore of 5 percent grade, equal to 150,000 tons of metal, for extensions to the east. The data were considered to be too scanty to warrant any attempt to estimate reserves in the other deposits.

Since the world's consumption of antimony is of the order of 17,000 to 18,000 tons per year, of which China now supplies 13,000 to 16,000 tons, and the cost of production

1 "The Wah Chang Mines, China," Mining and Scientific Press, July 10, 1915, p. 53.
2 "Antimony Production in Hunan Province, China," Trans. Inst. Min. and Met., Vol. XXV, 1915-16, pp. 366-389.
3 "The Mineral Resources of China," pp. 26-31.
4 "The Hsi-Kwang-Shan Antimony Mining Fields," Bull. Geol. Surv. China, No. 3, Oct., 1921, pp. 1-25.

in the latter country is below that of competitors, it would seem that for a long period China can dominate this market.

Mercury:—Among the minerals eagerly mined by the Chinese through a long term of years has been mercury or quicksilver, which was in demand as a base for making vermilion paint. It has been estimated that in the peaceful years of the last century the output rose to 1,000 tons per year, outranking the contemporary production of any other country. Disturbed political conditions, and perhaps exhaustion of mines, caused a decrease, so that in 1901 local mines furnished but 200 of the 510 tons consumed in China and by 1914, this had fallen to 130 tons out of a consumption of 370. At present, the output is probably much less, though exact figures are not at hand.

The important quicksilver mines are all within a belt 60 miles wide extending from western Hunan across Kweichow into southeastern Szechuan and northern Yunnan, some 425 miles. Most of the occurrences and virtually all the mines are in Kweichow. The district has been visited by F. R. Tegengren with C. F. Erikson and W. P. Loo, and is described [1] in one of the bulletins of the Geological Survey. He found the deposits to consist of irregular veins or stockworks in brecciated layers of limestone or hard shale with some dissemination of the cinnabar in the beds, as crystals and aggregates of crystals. The conspicuous feature of the more important deposits was that they occurred in elevated anticlines where the older, probably Ordovician limestone, is exposed, and are not known elsewhere. They show close relations to the geologic structure, but no igneous rocks are known in the district though present in the surrounding region. It is inferred that the deposits were formed in the Tertiary period and are related to underlying intrusives.

The data available did not permit Tegengren to make any estimate of reserves or even to reach a certain conclusion as to the average tenor of the ore. He considered, however, that the ores being worked in 1915 would contain less rather than more than 1 percent of mercury, though

[1] "The Quicksilver Deposits of China," F. R. Tegengren, Bull. Geol. Surv. China, No. 2, Oct., 1920, pp. 1-35.

occasionally rich ore up to 4 percent is found. While the area in which the quicksilver is found is large, it is inaccessible, the grade is low, and expectation of finding richer ores in quantity cannot be great in view of the long period in which the Chinese have known and valued the deposits. The attempt of the Anglo-French Quicksilver and Mining Concession of China, Ltd., to mine these ores, beginning in 1899 and extending to 1911 was without profit. Since the stoppage of the work in the latter year by the revolution, no attempt has been made to resume operations.

Minor Minerals:—Molybdenum, cobalt, nickel, bismuth, arsenic, and many of the rarer minerals are found in China and are produced in small amounts, but no deposits of more than local significance are known.

General:—Non-ferrous minerals are found in all the countries of the Far East in variable amounts. In succeeding paragraphs the situation as regards Japan, Philippine Islands, Malaya and Netherlands East Indies is briefly reviewed. As to Siberia, the Pacific provinces are known to be rich in placer gold and may contain deposits of secondary rank of a number of the other minerals. One zinc mine, near the coast north of Vladivostok on Tiutiuhe bay,[1] has been worked for a number of years and has produced as much as 25,000 tons of zinc ore, in the form of carbonate, and 4,500 tons of lead-silver ore in a single year. It is reported now to have a reserve of 840,000 tons containing 10.8 percent lead, 13.2 percent zinc, and 8.2 ounces of silver.

So much has been written concerning Siberian gold placers, and the information is so easily accessible, that it hardly seems worth while to do more than mention sources. A convenient summary and introduction to the special literature of the subject will be found in Maclaren's book.[2]

In Indo-China a wide variety of minerals is present and ample notes on their occurrence will be found in the reports of the Geological Survey of that region. Minor amounts of tin and tungsten have been shipped and larger tonnages

1 Purington, C. W., Eng. Min. Jour., Vol. 113, 1922, p. 362.
2 "Gold," pp. 210-225.

of zinc ore, the latter mainly in the form of carbonate. In 1925, the export of zinc ore was just under 50,000 tons. A zinc smelter has been built at Quang Yen. Lead and copper have also been mined in small amounts but up to the present the evidence available indicates that Indo-China resembles South China in having a considerable number of small mines producing many different minerals and will not contribute large amounts of any of the minerals.

In Japan mining is an ancient industry and began with the necessity of finding a domestic supply of metal as a basis for coinage and to permit construction of large Buddhist images for the temples. According to the handbook on "Mining in Japan" distributed by the Japanese Mine Owners Association at the Sesqui-Centennial Exposition at Philadelphia in 1926, the oldest record of mineral production is of the presentation to the Imperial Government of a quantity of oil produced in Echigo. In 700 A. D., a policy of encouraging mining was adopted and by the year 1000 A. D. mines had been opened on a fairly large scale, and in the Tushima silver mine workings had extended to a depth of 1,100 feet. Many of the mines now operated in Japan were discovered more than 1,000 years ago, and by 1685, there were 34 of record employing 200,000 persons and yielding 12,000,000 pounds of copper and 5,800 pounds of silver. The annual mineral production in 1924 amounted to 412,808,330 yen in value, coal accounting for more than half.

Details covering production of the principal non-ferrous minerals are given in the table below:

PRODUCTION OF NON-FERROUS METALS AND ORES IN JAPAN[1]

(For the Year 1924)

		Amount	*Value (in Yen)*
Copper	lb.	140,499,763	48,672,363
Gold	troy oz.	385,321	15,956,626
Silver	troy oz.	3,591,076	5,793,727
Zinc	lb.	31,256,150	5,554,640
Lead	lb.	6,534,885	969,862
Tin	lb.	770,010	864,900
Pyrite	metric tons	220,455	3,030,076
Manganese	ore metric tons	7,582	218,544

1 From "Mining in Japan," 1926.

Minerals of many varieties are widely distributed in Japan. The islands form the crests of a half-submerged chain of mountains which have an ancient crystalline core and around which Paleozoic sediments are found. In contrast with China, Triassic and Jurassic sediments are relatively unimportant and Cretaceous beds cover considerable areas both in the north and the south. The striking characteristic of the geology of Japan is the great series of volcanoes which in Tertiary and recent times have poured out masses of lavas and given rise to the great deposits of tuff.[1]

Copper is the most important of the non-ferrous minerals mined and for a number of years placed the Empire second among the world's copper producers. The metal is found in veins, impregnations, metasomatic deposits, and one important mine, the Besshi, works a bed of cupriferous pyrite in the ancient schists. The output of the five leading properties in 1924 was as below, the figures being in pounds:

COPPER PRODUCTION IN JAPAN

Ashio	31,084,383
Besshi	27,614,084
Kosaka	18,675,435
Saganoseki	16,719,970
Hitachi	16,670,140

These mines are all well-equipped and, while old, show promise of being able to keep up their production for a long period. At the Ashio mine the ore is mainly in a liparite intrusive in the older Paleozoics. The chief mineral is chalcopyrite but pyrite, pyrrhotite, zinc blende, galena, and arsenopyrite are also found. There are a multitude of small veins and occasional bonanzas due apparently to replacements of wall-rock. The crude ore sent to the mill is reported to contain 5 percent copper.

The Besshi mine, as already indicated, works on a bed of cupriferous pyrite which is 1,500 meters long. It is as narrow as 0.6 meters and as wide as 8. It has been mined to 670 meters below the outcrop. Much of the ore contains 5 to 7 percent copper. The Kosaka mine, in north-

[1] For a general account of the geology in English, see "Outlines of the Geology of Japan," Imperial Geol. Surv. Japan, Tokyo, 1902. Also, "The Geological and Mineral Resources of the Japanese Empire," Imperial Geological Survey, Japan, 136 pages, Tokyo, 1926.

ern Japan yields a so-called "black ore," an intimate mixture of various sulphides and baryta. The Saganoseki works draw their supply from a number of mines belonging to the Kuhara company which also controls the Hitachi mine where pyrite and chalcopyrite occur together and must be separated by flotation. According to K. Kinoshita [1] the ore occurs in five large lenticular masses in amphibolite. The Honko deposits is given as 450 meters long and 4 meters wide; the Kammine 300 by 7; Chusei, 400 by 6; Akazana, 120 by 14; Takasanzi, 150 by 12. The average ore now mined contains 2.46 percent and a small amount of gold and silver.

A recently discovered mine,[2] the Tsuchihata of the Tanaka Mining Co., is said to contain an ore-shoot 650 by 800 feet in cross-section and has been developed to a depth of 300 feet.

Gold is found at many points in Japan, occurring as veins, impregnations, in metasomatic replacements and contact deposits. The placers have been almost entirely exhausted though in Korea placers are still mined. The principal gold production comes from the following sources as shown by the output in 1924, the figures being in troy ounces: [3]

GOLD PRODUCTION IN JAPAN

Saganoseki smelter	61,666
Unsan Mine, Korea	61,432
Hitachi Mine	55,201
Taio Mine	36,250
Kushikino Mine	30,740
Besshi Mine	14,538
Rippo Mine, Korea	13,357
Saddo Mine	1,885

Silver is also found in all parts of the islands occurring largely in veins where worked for gold and silver alone, but here as elsewhere, the greatest production is as a by-product from smelting copper and lead. Six mines and two smelters, each of which in 1924 yielded from 200,000 to 575,000 ounces, together accounted for 3,126,438 ounces.

1 "Geological and Mineral Resources of Japanese Empire," p. 87.
2 "Progress in Mining in Japan," J. Yokobori, Eng. Min. Jour., Vol. 122, p. 506, Sept. 25, 1926.
3 "Mining in Japan," p. 8.

Lead is not an important metal among the products of the country, the mines being unable to supply more than 10 percent of the domestic demand. During the War, a smelting industry based upon imported ore was built up but it has since languished. The most important lead mine is the Kamioka, which yielded 5,417,363 pounds in 1924.

Zinc has been known for many years but prior to 1905 was regarded merely as a nuisance in smelting ores of other metals. In that year exports of the ore began and about 1911 smelting was established on a small scale. This was expanded in 1917 and ore was imported from various Far Eastern countries to supplement the domestic supply. Zinc blende is the principal ore and the largest output—23,374,155 pounds in 1924—comes from the Mitsui smelter at Miike. The metal is partly produced from imported ore. The most important mine is the Kamioka from which some 25,000 tons of concentrate comes annually. It is described by Kinoshita as being a contact metamorphic deposit, irregular in form and varying in thickness from 30 centimeters to 15 meters. The ore is a mixture of argentiferous galena, chalcopyrite and zinc blende associated with crysocola, malachite, pyrite, arsenopyrite and bismuth.

Tin has been long produced in Japan but at the close of the last century the only mines open were in the extreme south of Kyushu and the output was small. In 1909, a new mine, the Akenobe, was found in Hyogo and since then the production has increased largely. In 1924, the output from this mine amounted to 739,679 pounds and that from the older Suzuyama, 30,486 pounds. At the Akenobe mine, the tin is found with silver and copper in quartz. The Suzuyama vein is of the usual quartz-cassiterite type.

Bismuth is now produced in small quantity as a by-product of copper and lead smelting. The former antimony industry has disappeared as a result of exhaustion of the richer ores and the competition of Chinese mines. Ores of mercury, chrome, tungsten, molybdenum and other rare metals are known to be present, but apparently in quantities too small to permit establishment of any considerable mining industry. From such information as is available it seems probable that Japan, while possessing a wide variety

of non-ferrous minerals, does not have them in such quantities or in deposits of such size as will permit her to do more than supply domestic needs even with a very moderate degree of industrialization of her people.

The coal and iron deposits of the Philippine Islands have already been discussed. It remains here to say a few words regarding the minor minerals. The geology and mineral resources have been described in a report to which reference has already been made[1] written by W. D. Smith, than whom no one is better informed or more competent to pass an opinion. In summary he says:[2]

> "In some literature the number and the value of Philippine mineral deposits have been overstated. Although mineral deposits of one kind or another have been found in all parts of the Archipelago and though mineralization is widespread, I am compelled, after ten years' intimate acquaintance with the country, to say that very few already discovered deposits are of sufficient extent and richness to attract capital to undertake large-scale operations. The comparative geologic youth of most of the formation, the lack of persistence due to faulting and pinching, and the prevalence of archipelagic instead of continental conditions have affected the location, size, continuity, and value of the various deposits. . . . In spite of the impression which the above statement may give, I am of the opinion that there are some excellent possibilities in the Philippine mineral field. The country has not yet been thoroughly prospected."

It is true that prospecting has not covered the whole area with care and that in tropical countries prospecting is difficult and expensive, but many experienced American prospectors have been in the country and the number of discoveries that have warranted development have been few. Copper, lead, zinc, gold, silver, molybdenum, tungsten, chromite, platinum, and manganese are all known to occur, but none has led to any significant mining development save manganese and gold.

1 Geol. Min. Res. P. I., 559 pages, Manila, Bureau of Printing, 1924.
2 Op. cit., p. 356.

Of manganese ore there is a recorded production valued at 51,500 pesos in the years 1907 to 1920 inclusive,[1] of which nearly three-fifths was shipped in one year, 1916. In the same years the total gold output was valued at 22,-943,614 pesos. For the last ten years it has consistently amounted to more than $1,000,000 a year, but despite the success of the established mines there has been no expansion. The leading mine is the Benguet near Baguio, on Luzon. From the commencement of operations in 1906 to the end of 1920, the mine had yielded 143,793 tons of ore from which gold to the value of 4,983,750 pesos had been recovered and dividends totaling 1,250,000 pesos paid. At that time the reserve stood at 132,910 tons, estimated to contain gold to the value of 4,647,800 pesos. In the Aroroy district on Masbate, the two leading mines are the Colorado and the Syndicate. They are on quartz veins in adesite and related rocks, ordinarily 5 to 10 feet wide but occasionally broadening out. The ore reserves are moderate and while there are large long veins in the district, the grade of any ore mined on a large scale will be low. The third district of importance is the Paracale-Mambulao where a number of small veins have been worked at various times and where in 1915 nine gold dredges were operating in placer ground derived from the decay of the rocks. The field proved to be limited and all but one of the boats have worked out their ground.

Aside from the three districts mentioned, mining of metals is an unimportant industry in the Philippines, and while something of this is probably due to the uncertainty of the political future of the Islands and other artificial conditions, most of it is the natural result of the smallness of the ore-shoots so far found. The mines and prospects already located have been examined by many competent engineers. An experienced San Francisco group kept an excellent scout in the Islands nearly a year, long before the present uncertainties as to the future of the government had arisen, and in 1915 and 1916 a strong New York company kept two excellent men in the Islands nearly two years. They examined and sampled many properties, but were un-

[1] Smith, op. cit., pp. 352-353.

able to find any mining property justifying investment of large capital.

The Netherlands East Indies are well mineralized and may be expected to play an important part in supplying the world's needs. The important non-ferrous minerals now mined are gold, silver, and tin. Copper, lead, zinc, nickel, platinum, chromium, tungsten, mercury, molybdenum, bismuth, antimony, and arsenic are known to occur. Of these there is a small production of tungsten in connection with tin mining and a few ounces of platinum are recovered from Borneo diamond mines. In the opinion of Brouwer[1] the nickel found in the residual deposits of the lake region in Celebes may become commercially important. Since the lateritic iron ores of this district contain as much as 1 percent nickel and 2½ percent of chromic oxide, it is possible that both may come on the market in some form when the iron ores are worked.

The most important gold-silver mines are found near Benkulen in western Sumatra, the Redjang Lebong and Simau being the best known. The Mangani and Salida, also on the west coast of Sumatra, are essentially silver mines with gold subordinate, while the Tokok, Paleleh, and Bolang, in the Northern Celebes, again are dominantly gold yielding. The mines in Sumatra represent the type commonly found in Tertiary deposits and are characterized by the high grade of the ore. There are three classes of veins in this instance: (a) selenium-gold; (b) manganese-silver; (c) sulphide-gold-silver. All have proved profitable and, since an extensive area is underlain by the same rocks and covered by dense tropical growth that restricts prospecting, it is to be expected that more deposits will be found.

In general, the sulphide minerals, copper, lead, and zinc, have not as yet proved to be quantitatively important in these islands, though Brouwer mentions a number of localities at which they occur. Tin is important and from the three islands of Banka, Billiton and Singkep is mined annually an amount second only to that obtained in the Federated Malay States.

1 Op. cit., p. 116.

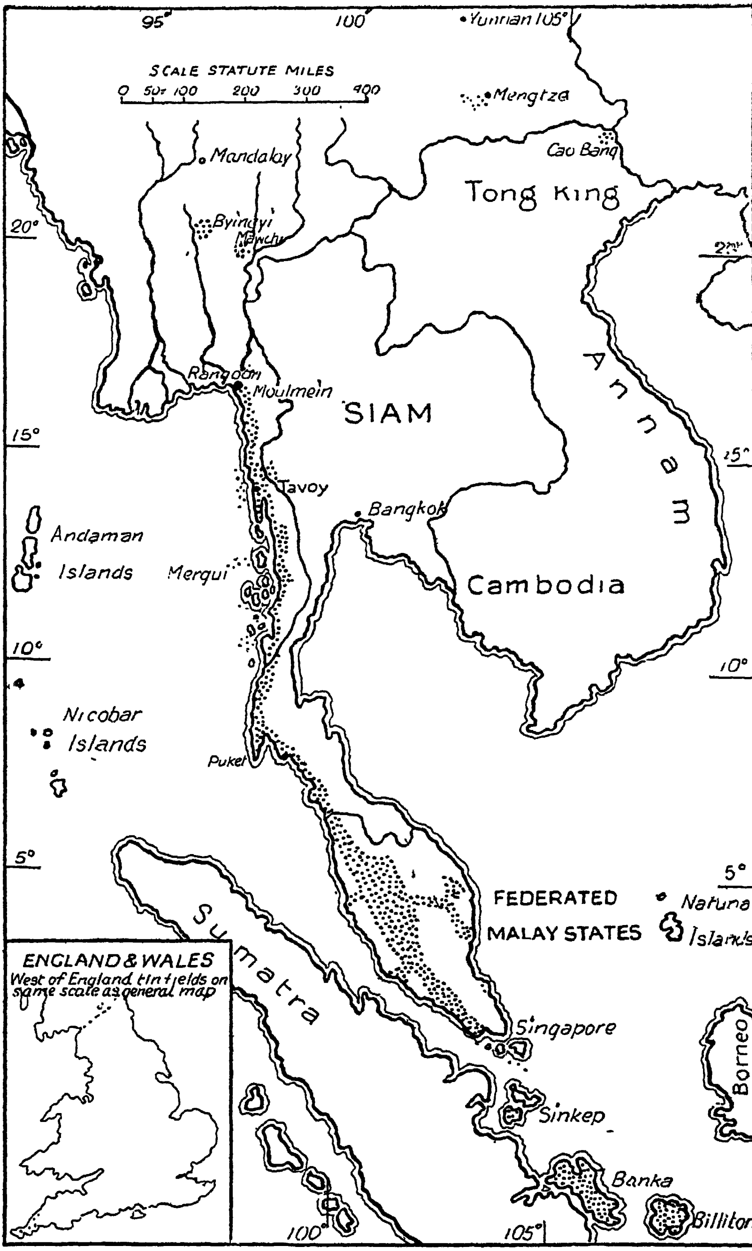

FIG. 19. *Map showing location of tin fields of the Far East; after W. R. Jones. By permission of Mining Publications, Ltd.*

For convenience the deposits of tin on the whole Malay Peninsula will be discussed here, including those of both the Federated and Non-Federated Malay States as well as those of Singkep, Banka, and Billiton belonging to the Netherlands East Indies and of Siam. There is little evidence that mineral deposits other than tin exist in Siam in such size as to warrant expectation of important contributions to the world's supply, and the tin ores from all these countries are of the same character. A limited amount of tungsten comes from the tin districts, but the main output of tungsten comes from farther north in Burma. Gold, too, is mined in a small way at a number of points from Siam south, but essentially the Malay Peninsula from end to end is a tin producing country. As such it ranks first in the world and in 1925 furnished 60 percent of the world's output. The figures of production for the individual countries in this belt are as given below:

PRODUCTION OF TIN FROM MALAYA[1]
(For the Year 1925)

Federated Malay States	45,925
Netherlands East Indies	32,749
Siam	6,802
Non-Federated Malay States	2,500

The total, 87,976, corresponds, as indicated, to 60 percent of the world's total for the year, 144,788 tons. The region is of first importance not only by reason of the large output but also of the high quality of the tin made from its ores.

An abundant technical literature descriptive of the geology, ore deposits, methods of working, and economics of production in this region is available. W. R. Jones, some time a member of the Geological Survey of the Federated Malay States, later a mine operator at Tavoy in Burma, and a recognized specialist on tin and tungsten, has recently written on the "Tin Fields of the World."[2] He has summarized excellently the important features of the great tin-tungsten field extending from Burma to Sumatra,

[1] As compiled by Amer. Bureau of Metal Statistics; figures in tons of 2,240 lb. There is also an excellent review embodied in the report on "Tin in 1925," by J. W. Furness, forming pages 65-88 of "Mineral Resources of U. S., 1925, pt. 1. United States Bureau of Mines, Washington, 1926, 423 pages.

[2] Mining Publications, Ltd., London, 1925.

on the basis of wide personal acquaintance with the field as well as the literature. For details as to particular mines and districts, readers may be referred to his book and the special papers cited therein.

Geologically, the backbone of the Malay Peninsula is a range of granite which extends from Burma south. The granite has been intruded into older Paleozoic rocks, originally limestones, sandstones, and shales, which have been partly metamorphosed into marbles, quartzites, slates, and schists. The intrusion of the granite resulted in the faulting, folding, and crushing of the sedimentary rocks, and was accompanied by the introduction of tin and tungsten in small veins in the upper part of the granite and the adjacent sedimentary rocks. As already suggested, the veins are dominantly filled with tungsten minerals to the north and with cassiterite to the south. The rocks have yielded to decay under the influence of moist tropical climate and there has been extensive slumping of the material, especially where sink-holes and solution-cups have been formed in the limestone. In places there has been actual movement and redeposition of the tin in true placers, but in general the deposits worked are detrital and the tin is essentially in place even where the deposits do not consist of merely the softened rock itself. The area affected is extensive and mineralization has taken place on both sides of the mountain range, though most of the mining has been on the west side. As to the area affected, Jones remarks:[1]

> "So extensive is the mineralization in, and near to, the granite that occupies a large part of the surface of the Peninsula that the author came to the conclusion, during the course of his geological work in the Malay Peninsula over a number of years, that it would be difficult to find any small stream, having its source in the Main Range, that did not contain in its bed a certain amount of tinstone. In fact, the beds of practically all such streams have, at one time or another, been worked for tinstone."

According to J. W. Furness[2] in 1925, there were 44 bucket dredges and 8 suction-cutter dredges in operation,

1 Op. cit., p. 161.
2 Op. cit., p. 78.

mining 20 percent of the entire production. Gravel pumping accounted for 27 percent, hydraulicking 11 percent, open cut 4 percent, ground sluicing 18 percent and fossicking 6 percent. Lode mining yielded only 6 percent.

The tin is mined almost entirely from open pits, and of recent years an increasing proportion has been won by dredging. One of the largest individual producers, however, is the Pahang Consolidated which is mining a number of lodes varying from a few inches to 10 feet in thickness, and whose workings now extend to 2,118 feet in depth. In the year ending July 31, 1926, this mine produced 198,800 tons of ore from which 2,536 tons of concentrate was made. While no other lodes of corresponding importance have as yet been opened in depth, the experience of this company suggests that even after the placer ground shall have been exhausted an important though smaller amount of tin may continue to come from this region. No careful survey of reserves has been made except in the Netherlands East Indies, where a committee has reported that the proved areas on the Island of Billiton are sufficient to insure a continuance of the present output of 7,000 to 8,000 tons per annum for 10 years only. The ore reserves of Banka were estimated as of 1925 to contain 206,800 tons of possible and probable metallic tin,[1] taking the concentrate at 70 percent in content and reducing piculs to long tons. The actual reserve was placed at 160,963 tons of ore and the probable at 134,519. Some tin is now being produced from Sumatra.

Jones, commenting on the Billiton estimate, makes the statement,[2] "that ten to twelve years hence the bulk of the rich secondary deposits of the Dutch East Indies, of Malaya, of Siam, and of Lower Burma, will have been exhausted." Whether or not the time will prove to be as short as he anticipates (and it is to be remembered that there remain virtually unprospected extensive areas east of the mountains in which some tin has been found), it is true that placer deposits are characteristically short-lived. In the long run it will be the lode mining districts that will supply the tin of the world.

1 Bangkatinwinning, Verslag Over Het Exploitatiejaar 1924, 1925, p. 6.
2 Op. cit., p. 231.

CHAPTER VII

NON-METALLIC RESOURCES

THE minerals belonging to this group are those of industrial use which are mined essentially for other purposes than their metal content. They form the raw materials for numerous industries and they are often essential to the conduct of enterprises of large importance, though not entering into the product itself, as in the case of infusorial earth which is used for filtering oil and chemical solutions. Coal, petroleum and sulphur are all non-metallic, but because of their major importance they have been discussed separately.

Fortunately, the non-metallic minerals are much more abundant and widely distributed than the metals, and a country deficient in the latter may well have an abundant supply of the more common raw materials suitable for industries of a different type. It is also true that many of the non-metallic minerals, using that term in the industrial sense, contain metals, and under proper conditions these can be reduced and substituted for others commonly used elsewhere but locally deficient. A common illustration is that of aluminum, which occurs widely distributed as a chemical constituent of clays and is produced commercially from bauxites. For some few purposes aluminum and its alloys can be substituted for steel, but for most of them it is useless. Unfortunately, it costs about ten times as much to make aluminum even from bauxite, a relatively scarce mineral, as to produce steel even from low-grade iron ores. The amount of energy necessary to make the conversion is greater and there are no satisfactory reasons for anticipating that aluminum will ever be really cheap as compared with steel. To make it commercially from clay has heretofore proved impracticable though the chemistry of the process has been worked out. Our present knowledge, therefore, does not warrant any cheerful assumption that shortage of

steel will be made good as a matter of course by production of aluminum from clays.

The same applies to many other suggested substitutions, all or nearly all of which fail because of the unsatisfactory character or the high cost of the substitutes. Use of alloy steels in place of ordinary carbon steel reduces the amount needed but at a cost that so far has proved prohibitive save for special uses, as in the manufacture of motor cars. While the Far East, especially China with its large coal resources, will be able in some degree to make good by substitution for its deficiency in metals, in general it seems probable that here as elsewhere the usual rule will hold good; it will prove more satisfactory to pay for transportation from the point of cheapest production than to attempt to manufacture from poor and scattered materials or to substitute others entirely.

The number and variety of the non-metallic minerals is so great and they are used in so many ways that no classification is entirely satisfactory. For present purposes they may conveniently be discussed under the following headings: (a) Building Materials; (b) Industrial and Chemical Raw Materials; (c) Fertilizer Minerals; (d) Salt; (e) Gems and Ornamental Stones.

Building Materials: As has already been suggested, those countries still having adequate supplies of wood—Netherlands East Indies, Malaya, Siam, Philippines, Siberia and Japan—employ it freely in construction of buildings. Japan has begun to feel the pinch and has turned largely and most intelligently to forestry to make good the supply. Wood, too, is supplemented by paper and plaster in cheaper construction and brick, stone, and tile are more and more being used. Tile has long been a favorite material for roofing in Japan [1] though the old Imperial palace at Kyoto is thatched with narrow strips of wood carefully built up to a thick covering. In the other countries mentioned brick, stone, and plaster have long been used for more important

[1] For a general summary of the non-metallic minerals of Japan, see Y. Oiniouye, pp. 103-107, in "The Geology and Mineral Resources of the Japanese Empire," Imp. Geol. Surv., Japan. Tokyo, 1926.

buildings and are coming into wider and wider use under modern conditions.

In China, the supply of wood has long been too limited for free use in building. The material commonly used is brick with tile for roofs. Stone is widely used, in fact wherever available, even for exceptional purposes. Talifu marble, an ornamental variety, is used as panels in the backs of chairs. Elaborately carved limestone may even be seen cut to slide in grooves in other limestone blocks so as to form valves for the control of ditch waters. Such an instance as the latter illustrates the general poverty of the country in wood and iron.

The brick commonly used in China is soft burned. In fact, it is ordinarily dark in color having been burned entirely in a reducing atmosphere at low temperature. Much of it is made from loess in field kilns having mud walls, straw roofs and wooden grate bars protected by clay. The kiln is fired with field refuse, straw and brush, and only rarely with coal. Such brick is weak and even with thick walls it is necessary and customary to support the heavy tile roof on a wooden framework corresponding in purpose to the structural steel used in American city buildings. In parts of the country, and in cheaper construction, the brick is not even burned but is sun-dried, and adobe structures with thatched roofs are common. Dirt, brick, tile, and stone floors are common, though where lumber is available it is used. As is well known, oiled paper is commonly used for closing windows, the wind pressure being taken care of by means of artistic and ingenious wooden lattices that add much to the attractiveness of a Chinese house. As indicating the general absence of iron it may be mentioned that in the villages the doors commonly swing on wooden corner pivots.

The scant use of hard-burned brick, of good mortar, and of glass is directly due to poor distribution of coal. The materials are all available in the country and the Chinese have long known their use. Where coal is available, excellent brick is made at remarkably low cost, the industry being one well adapted to Chinese labor. Modern brick yards are springing up everywhere and in Japan and the chief cities

of China good red brick is coming to be widely used.

The ordinary mortar of the Far East is old-fashioned lime mortar made from local materials. Lime-burning is practiced in all of the countries and calls for no especial remark. The necessary rock is nowhere absent over large areas. Gypsum plasters are coming into use. W. H. Wong [1] estimates that 50,000 tons of gypsum are now mined annually in China, mainly in Hupeh and Hunan. Much of this is used as a retarder in the manufacture of cement, but it also finds use as a plaster and in the fertilizer trade. Gypsum is also found in Japan, the Philippine Islands, and elsewhere and gypsum mining is one of the industries that may be expected to increase.

Cement manufacture is one of the newer and growing industries of the Far East. There, as elsewhere in the world, the tendency to substitute high-temperature cement for poorer building materials is to be observed. In view of the general poverty of these countries in steel-making materials, it is to be anticipated that cement will come into wider and wider use and that with the progress of industry in the Far Eastern countries the people will come to depend upon cement more and more. Fortunately, the constituent materials, limestone and shale or clay, are widely distributed and their quality has already been proved. There are large modern plants in Japan, China, and Hongkong and less well-established industries elsewhere, as in the Philippines.

In China, cement manufacture began before the close of the last century when what is now known as the Chee Hsin Cement Works was founded. At present, there are nine companies listed in the China Year Book,[2] as below:

	Location	*Capacity*		
Chee Hsin Cement Co.	Tongshan	4,750,000	bbl.	yearly
Hupeh Cement Works	Tayeh	360,000	"	"
Canton Cement Co.	Canton	200	"	daily
Onoda Cement Co.	Dairen and Paotzeni, Manchuria	200,000	"	yearly
Green Island Cement Co.	Hongkong, Kowloon, and Macao	100,000	"	"
Shantung Cement Co.	Tsingtao	300	"	daily
Shanghai Cement Co.	Lunghwa	1,200	"	"
China Cement Co.	Luntan	500	"	"
Hai Hu Cement Co.	Wusih	1,000	"	"

1 China Year Book, 1925, p. 140.
2 Edition 1925, p. 519.

The amount exported in 1923 was of a value of over \$1,500,000 gold but the larger part is used within the country. Julian Arnold has pointed out that per capita consumption of cement in China now amounts to 3 pounds per annum as compared with 85 pounds in Japan and 450 pounds in the United States, showing large room for further expansion. Common coals of the Far East, being of high volatile type and burning with a long flame, are well adapted for use in cement kilns and the processes of manufacture are now well understood and standardized. Just how far the usual methods of manufacture are to be superseded by those involved in making the new quick-setting alumina cements, is uncertain in Europe and the United States, but in the Orient where first cost is more important and time much less a matter of concern, the ordinary cements may be expected to find place for themselves for a long, if not an indefinite time.

Stone for building is widely distributed and slate for roofing is known and is worked in Japan especially. The preference of the people for tiles, their skill in making them, and the abundance of material for their manufacture, all point however to the probability that they will be most used as roofing material in the future as in the past.

Sand, gravel, and rock for crushing are widely available save on the great plain of China, where in building the Tientsin-Pukow railway line it was necessary to burn and crush brick in order to obtain a suitable material for ballast. In constructing a system of modern roads through the area, which seems to be the next great task before the engineers of the country, the same material could be used, though it would probably be better and cheaper to haul in crushed rock from the surrounding mountains. As already indicated, most of China and Japan is mountainous and therefore rock for crushing is widely available. In Indo-China the wide plains on which most of the cultivation takes place are underlain by gravels, from which the French engineers have made excellent roads. In the Philippines, the American engineers found no lack of road material and in the Malayan countries the roads made by the British and Dutch are famous. In those countries lateritic deposits are wide-

spread and form an excellent material for surfacing, since the traffic is light. Bituminous rock is found in Japan, the Philippines, and in a few localities in China, and where available can be used to advantage. The difficulties in building modern highways in the Far East arise from other sources than lack of material.

Industrial and Chemical Raw Minerals: This group includes a wide variety of minerals finding many uses, usually in small amounts. Abrasives, for example, are of many kinds and used for many purposes. Those suitable for ordinary use are not lacking in the Far East. Millstones, grindstones, garnet sands, pumice and diatomaceous earth are widely distributed. Volcanic ash is found in the various districts where volcanoes are or have been active. No peculiar supply of any abrasive such as might contribute importantly to world trade is, however, known.

Refractories, such as dolomite and magnesite, are known in various countries and have been used in China. The bauxites of the Malay peninsula may come into use as refractories and at several points in China and Japan, firebrick is made from the clays found associated with the coals. Graphite has been mined in Japan and Korea. In early years the Korean production was of the amorphous variety, but during the War an output of flake graphite was developed and shipped to Japan. The amorphous graphite mined is used largely for foundry facings. The total production of graphite in Japan, according to the handbook of the Japanese Mine Owners Association, has been as below:

	Pounds	*Value in Yen*
1920	24,908,625	300,047
1921	16,026,692	208,902
1922	33,419,191	295,760
1923	31,697,513	258,215
1924	33,209,108	277,142

Asbestos is reported from many points in China and Japan and from the Philippines [1] but is not as yet an important article of trade. Mica is present but not yet developed. Talc, ocher, and other materials used for fillers, pig-

1 W. D. Smith, op. cit., p. 358.

ments, and glazes have been carefully sought out in China and Japan and long used. These industries are well understood, paper-making and pottery manufacture being ancient arts, and local supplies have so far proved ample for all demands.

Clays for the manufacture of pottery, chinaware, and porcelain are found at many points. The very names "kaolin" and "china" clay come to us from the East. There is an abundant literature descriptive of the ceramic products of China, Japan, and the other Eastern countries which it would be aside from present purposes to review, though in view of the artistic skill of the workers and the high traditions of the art ceramic products may be expected to constitute an important group among the exports of the Far East.

Fertilizer Minerals: The Eastern countries, with their long history of continued occupation of the same land, and the devotion of their people to agriculture, have had occasion to study closely problems of soil fertilization. Wide use is made of manures and other organic materials, but so far no large supply of mineral fertilizer has been found nor are large importations common. Discovery of deposits of potash, nitrates, and phosphate rocks would be of the greatest possible benefit to the peoples of the various countries, not only in that the use of the concentrated mineral fertilizers would decrease the amount of hard and disagreeable labor now necessary, but it would then be possible to raise fruits and vegetables free from pollution and so improve the general health of the country.

Phosphate rock is easily overlooked. It has happened repeatedly that large areas of valuable rock, even within the limits of producing districts, have been passed by for years by experienced geologists and engineers. It is accordingly possible that in the great areas of older limestone, such as occur in China in particular, considerable bodies of phosphate rock remain undiscovered. The importance of the matter has been kept fully in mind by the geologists of the various countries, and the staff of the Geological Survey of China has systematically tested all limestones col-

lected in the course of other work, but so far without success. In Japan, phosphate is found in the Tertiary formations of Hyuga, Uzen, Ugo and other provinces. The content of phosphoric acid is small, 10 to 20 per cent.

At present, the chief source of phosphate is from the Pacific islands of which Naru, under British management, produces about 150,000 tons per year. From Makatea, the French ship 30,000 to 40,000 tons. Anguar is controlled by the Japanese and Daito and Rasa are under Japanese mandate. The last is now the most productive, the deposits being reported to be as much as 20 meters thick.[1]

The total Japanese production of phosphate rock in recent years, as given by the Japanese Mine Owners Association handbook, has been as below:

	Metric Tons	*Value in Yen*
1920	97,340	3,880,619
1921	32,001	846,239
1922	12,320	236,051
1923	33,107	612,152
1924	85,617	621,660

Pratus island, near Hongkong, is reported to contain phosphate and belongs to China. It has not been developed. Guano is collected from various islands along the west coast of Siam and the Malay States and from caves in the Philippines.[2] Tuffs and limestones enriched by guano are also reported near Dumarao. C. C. Liu has described[3] a deposit of apatite replacing limestone in the older rocks near Tunghai. The high-grade rock contains 49 percent phosphate or more. The commercial grade is reported to run 33 percent. Up to the time of Liu's visit in 1919, 6,000 tons had been produced and 2,000 tons shipped.

Neither potash nor the nitrates have been found in quantity in any of the Far Eastern countries though common salt is widespread and has been much studied and W. H. Wong mentions a number of salt lakes in Mongolia[4] in which natural soda is abundant. It is possible that in the interior of Asia or at depths in the areas here discussed

1 Y. Oiniouye, op. cit., p. 107.
2 W. D. Smith, op. cit., p. 384.
3 The Apatite Deposits of Tung Hai Hsien, Kiangsu Bull. Geol. Surv. China, No. 4, Oct., 1922, pp. 1-2.
4 China Year Book, 1925, p. 140.

supplies of these materials may be found. Exploration conducted elsewhere during and since the war has shown that potash is more widespread than previously supposed and new sources of supply are being developed both in Europe and the United States. As to nitrates, the world is turning to artificial products and there is opportunity for their manufacture in the Far East. Sulphate of ammonia is already made as a by-product from coking in Japan. The eastern countries do not have that abundance of cheap water power that warrants its use in making nitrates but the newer processes which depend upon burning coal are applicable especially where, as in China, coal is abundant.

Salt: Salt seems to be the one mineral that men must have and in every country its production is an ancient industry. In China, salt production is a government monopoly and by international agreement the collection of the revenue is under foreign supervision. The standard rate is $2.50 per picul and the total revenue for 1924 amounted to $81,433,354.[1] The salt in Szechuan and Yunnan is derived from brines obtained from springs and deep wells. The drilling of those in Szechuan constitute a distinct achievement in the ancient mining art of China. The salt made in the coastal provinces comes from evaporation of sea water. Salt is produced in all the other countries to meet local needs, being derived by evaporation from sea water or brines.

Gems and Ornamental Stones: Eastern people are very appreciative of beauty in the precious and semi-precious stones and use many of them. The great sources of supply are Ceylon and Burma but minor quantities are found in various other countries, and China and Japan are both countries in which gems are extensively cut and carved. Diamonds are produced in Borneo and small diamonds are found in Shantung. Amber is, to a limited extent, found in Japan as also the ruby, sapphire, beryl and topaz. Most of the amber cut and sold in the East comes from imported crude stock. Jade, a stone most widely appreciated, is mainly cut in China, though the crude rock comes from the

1 China Year Book, 1925, p. 776.

Northern Shan States in Burma. Sapphires are exported from Siam. Quartz in its various forms is mined and cut in various countries. The Eastern people seem on the whole to be more likely to be buyers rather than sellers of the precious stones, though their exquisite craftsmanship may well lead to development of a large cutting industry and trade in such materials.

CHAPTER VIII

CONDITIONS AFFECTING MINERAL DEVELOPMENT IN THE FAR EAST

In the preceding chapters of this book the available data have been summarized which bear upon the character and occurrence in the Far East of those mineral deposits that are required if the ancient civilization of the Orient is to be transformed into the type of industrial civilization dominant in the West. It has been shown that with minor exceptions, such as tin, tungsten, antimony and ceramic products, the minerals are not present in such quantities and situation as warrants expectation that they will contribute heavily to world trade. In general, the Far Eastern countries will need to import, rather than be able to export, metals and minerals if its peoples ever approximate the per capita consumption of these materials obtaining in the United States and the leading countries of Europe. There remain to be considered certain facts as to distribution and as to the habit of mind of the peoples that must be taken into account in any attempt to estimate the future development of the mineral resources of the countries concerned and to evaluate its rate. In discussing them, China will again be taken as the leading example since the Chinese are the most numerous of the peoples of the East and have the longest historic records on which to base judgment. There are important differences in the various peoples, but there is also a psychology of the East which the Chinese have and which dominates the entire area.

In studying the possible development of mining and metallurgical industries in any region, it is necessary to determine the resources not only in material but in men and money.

As to men, there is no lack of labor force in any Eastern country, even after discounting heavily, as any student must, the stories of overpopulation based upon data collected in the more accessible regions and countries. It is out of the question to obtain any entirely reliable figures of population and even those of area are but approximations, but the following will give a notion of the order of importance of the various Far Eastern countries as regards both:

AREA AND POPULATION OF FAR EASTERN COUNTRIES [1]

	Area (*Square Miles*)	*Population* (*Thousands*)		*Density* (*Square Mile*)
China	4,278,352	427,679		100.0
Br. India	1,091,056	247,003		226.4
N. E. Indies	733,642	49,351		67.3
Indo-China	274,457	19,748		72.0
Siam	200,148	9,410		47.0
Japan	149,792	55,963		373.6
Philippine Ids.	115,026	10,314		89.7
Korea	85,227	17,264		202.6
Taiwan	13,839	3,654		264.0
TOTAL	6,941,539	840,386	Average	121.0

Abundance of "raw material" does not assure a satisfactory output whether one be discussing actual goods or labor. If all the men are now engaged in industry and cannot be shifted, there is clearly no available labor regardless of population figures. A surplus of brokers in New York is not a present help to the Kansas farmer when he faces a shortage of field hands, and as to the Far East it is not always remembered that the people now there are at work, or at least in most of the countries under discussion if they were not at work they would not be there long. Also they are working under an organized system which in many instances is close-knit both with economic needs and religious ideas. Americans will not soon forget the widespread economic and social disturbances brought about by the war-time necessity of shifting labor to man the ship yards; and American labor is not only vastly more mobile than is that of the Orient, but in this instance there was no such break with traditions and built-up economic relations

[1] Source: Taiwan from Statesman's Year Book, 1924. All others from Statistical Abstract of the United States, 1924.

making for future security as is involved when an Indian ryot breaks caste and becomes a coal miner or a Chinese farmer neglects his planting in order that an American mine may be operated the year around. In the East there is an abundance of labor to be had on the terms of the laborers, but a scarcity upon such terms as are necessary to sustain large-scale industrial undertakings. It is not solely a matter of wages. It means a readjustment, or rather a remaking, of a whole social structure, except in so far as the newer industries may be fitted into the older. For work which may be treated as an avocation there are willing workers; but if the matter must be treated seriously as a vocation, difficulties multiply.

The limit on coal supply in India in war years was not due to any inability to find coal or to open collieries, but to scarcity of steady workers. Coal mining not having been a large industry in India, there is no caste or large group of workers accustomed to it or willing to enter the vocation. Change of occupation in such a country is a much more serious matter than with us. Again, at the Bawdwin mine in the Northern Shan States, where a large proportion of the workmen is drawn from within China, the labor force melts away when the rains come and the planting season begins. Within two weeks it has decreased at times from 14,000 to 9,000 in numbers despite anything the company could do. Under such conditions there is, aside from the inconvenience, a heavy charge due to cost of arranging for work on a seasonal basis.

In China, when the winter season comes, the farmers crowd into the cities and towns and seek employment as coolies; but if an employer has transport to arrange in the crop-growing season he is likely to find carts and coolies fully employed and they will continue their regular work even at prices much below what he may be tempted to offer, since to fail to do so means that they get out of step with the economic and social unit of which each forms a part. Temporary employment is not worth that much to them. The building up of a cotton-spinning industry along the lower Yangtze upset the whole balance of industry in that region and in many of the small country villages the mis-

sionaries reported great distress because bread-winners had been taken from the farms and no substitution effected.

Much has been made of the crowded condition of Japan, of the increasing population bound, as by a steel ring, to an unexpanding area of arable land; and Japan has gone farther than any other Eastern country along the road from household industries to a factory system of production. The manufacturing industries of Japan have been growing at a startling rate, and yet the total achievement is small as compared with total population, if measured by standards in western countries. Even so, to furnish labor for the plants already built it was necessary to recruit heavily in Korea. Similarly, despite the free hand that Japan has had in Korea, the dominant position enjoyed for some years in Manchuria, and this necessity for outlet of which so much has been said and which is undoubtedly felt to be real by the Japanese, after ten years there were estimated to have been less than 300,000 Japanese in Korea and Manchuria all told. I would not like to vouch for the accuracy of the particular figures but it is safe to assert that the number was small. Recent estimates place the number of Japanese in Manchuria, after nearly a quarter of a century of free hand, at 170,000. Even an intelligent, active, and well-organized people such as the Japanese, faced by a real necessity, change their habits and vocations slowly.

This reënforces the observation that in planning for new industries in the Far East one must not assume that large or even dense population means abundant available labor. Undoubtedly men and women workers may be had, but recruiting and training them will involve not only direct expense but the further charge due to delay. It indicates that in this as in other ways, a large item of cost must be included in the estimates if it is considered necessary to try to hustle the East.

There is a further factor to be taken into account wherever Buddhism has made a deep imprint, as for example in Siam and Burma. Buddhism by its insistence on the transitory nature of all things, diminishes incentive to accumulation, and the desire to accumulate has been one of the most powerful factors in building up the material surplus

of the West. The religion of Buddha, where taught even in a form far from the purity of the essential doctrines, produces charming people of most admirable qualities, but people poorly equipped to maintain themselves under the harsh conditions of a fiercely competitive world. They make fine neighbors and friends, but for purposes of modern industry these populations all but fail to exist. It is not that they are incapable of intelligent effort; they do not believe in accumulation. While in the Burma oil fields it is true that native workers have been trained to do all the work inside the rig, it is hard to keep a steady force. Unless some way be found to reconcile their beliefs and ideals to those of our own, they will be nearly as useless to mine operators as a population of Quakers would be to a military chieftain.

Still another factor, one which is of increasing importance as one travels from North to South, is the prevalence of disease and the extent to which the workers' vitality has been sapped by malaria, hook-worm, and other parasitic diseases. The actual loss of earning power here runs into millions, and this is aside from losses due to deaths and to sporadic epidemics of various sorts. It is known that to a large degree such matters can be controlled, even in the tropics, if sufficient time, energy and skill be devoted to them. The demonstrations, however, have been made where public interests were involved and cost was at least a secondary consideration. Just how far an individual company can afford to go in a similar health and sanitation campaign has not, so far as I know, been made the subject of careful inquiry; and this must be done if mining is to be conducted on a large scale in the tropics either in the Far East or elsewhere. In the past, the mineral won from tropical countries has in the main been mined under labor systems where loss of life by the workers was regarded as of minor importance. This is now as impossible as it is undesirable, and the whole topic of labor efficiencies in the tropics is one which might well form the subject of careful investigation. Carl Crow, in discussing "A Nation of Invalids,"[1] has given a picture of the problem as it existed in the Philip-

[1] Chapter VIII, "America and the Philippines," New York, 1914.

pines when the Americans entered that country, and there are numerous individual studies. What is needed is careful summation and discriminating criticism of the data available. Chinese laborers seem to have built up considerable immunity to many diseases just as Chinese plants have, and Chinese are widely available in the East. American rubber companies in the Malay States are fighting mosquitoes and fevers along the lines of Canal Zone experience. But such work is expensive and constitutes a real charge against development and operation. Nicholas Roosevelt has recently pointed out the importance of this matter in considering the future of the Philippine Islands.[1]

One or two contrary tendencies need mentioning. From time immemorial great armies have been recruited in the Far Eastern countries, and to-day the plague of China is the number of men gathered into the service of various military dictators. These men serve for small pay and by no means always get even the wages promised. To gather a few hundred thousand workers for industry would seem a relatively simple problem. In practice, it has not proved so. To a considerable extent the armies of China have been recruited from the ranks of the bandits, and banditry is in many parts of the country a seasonal occupation that dovetails nicely into farming. When crops are bad a term of service as a soldier helps to make good the deficiency in income. All-year service as soldiers for large numbers of men is a relatively new phenomenon. The methods of recruitment and of holding men in a regular army can hardly be applied wholesale in industry, and effective work in industry is only possible with a contented and willing force. Life in a Chinese army, while by no means a perpetual picnic, does carry with it the chance for excitement and loot and appeals to the deep ingrained gambling instinct of the men more than would the regular grind of factory or mine work.

However, it is not here suggested that it would be impossible to recruit a capable force of miners; merely that it would involve much difficulty and expense and would require a material remaking of the social structure of the

1 "The Philippines," Nicholas Roosevelt, p. 213, 1926.

people. Miners constitute approximately one percent of the population of the United States. Allowing for the difference in efficiency, and in good Chinese coal mining it requires eight men to do the work of one American miner while in ordinary mines it takes half again as many, it would be necessary to recruit for mining alone many times the total number of men now in all the Chinese armies to permit any such wholesale change in consumption of fuel as will be necessary to modernize the Far East.

Another and a new factor in the situation is the quick rise of the power of labor unions and their current use for political purposes. This came as a surprise to many familiar with the East. The strength of the family bond has been so long the most powerful social tie in the Orient and industrial organization has rested so firmly on the guild, that modern labor unions have been thought unlikely to get a foothold. Despite the headlines now common in our newspapers featuring strikes in China, it is far from certain that labor unions, such as we know them in the West, are or will be strong in the East. It has long been characteristic of China, at least, that public opinion has been powerful and passive resistance is no new device for effecting political changes. Opinion has been organized through families and guilds. These are apt to be related since family villages and village industries go together. The economic margin for the individual in China has been so narrow that each has had to conform to the decisions of his family council, and it may well be that the leading families are back of the demands so-called labor unions have recently enforced in various communities. It may be that with growth of industry and improvement in communications the family tie is weakening in China as elsewhere, and new bonds may be in process of being forged; but the present social structure in China has grown out of and is best adapted to agricultural and household industries. To change the industrial output of the country will require proportionate change in the habits and life of its people.

Turning now to the matter of capital, it may be premised that this discussion is based upon the hypothesis that Amer-

ica now has and Europe will in time have a surplus which may be wisely invested abroad. The money now available is private capital. No one would be justified in the present condition of knowledge and experience in appealing to the general public for subscription to mining enterprises in the East. Neither can trust funds be so employed nor is banking capital available except temporarily and when secured by paper of independent value. This narrows the field materially, but still leaves available the money of individuals and mining companies who are thoroughly familiar with the risks of the industry itself and who have a sufficient stake in mining to warrant the expenditure of time and money necessary to obtain knowledge of the special field. This can be done most cheaply by coöperation since, having in view the distances and the inevitable delays incident to any work in the Far East, the expense of sending out an independent staff of examining engineers by each company for each project submitted, is prohibitive. Unfortunately, there is not, outside Malaya and Japan, any large existing body of knowledge of local mining. Nor, aside from those countries, is there any considerable body of resident engineers available for making examinations who are competent, free from entangling alliances, and well enough known abroad to give the necessary weight to their opinions. The amount of independent business in the East has been small and the first class men out there are necessarily committed in the main to some group or enterprise. Where they are not, the very years of residence in the East necessary to give them an intimate view has cut them off from cultivating acquaintance at home and, it must be added, from close contact with the necessities of a company or group at home which proposes to finance or operate in the East.

While there are exceptions, the history of American attempts to find mines in the Far East has been one long series of expensive expeditions to examine particular properties, most of which, for one reason or another proved unsuitable. It is highly desirable that, as rapidly as circumstances permit, there should grow up in the various countries concerned groups of engineers and local financiers who will select from the mass of prospects those which seem worthy

and make the investigation leading to undertaking development, necessary to prepare them for presentation to capitalists of experience in America and Europe. At present there are virtually no such groups, and properties are presented with a lack of data or even with a confusing mass of inaccurate data. There is here a gap between the large mining company or investor on the one hand and the prospector or land owner on the other which exists to some extent in all countries. In the Far East it is even more apparent because there is no body of local opinion familiar with the standards set by mining practice in the West. Perhaps the gap cannot be bridged save by coöperation between East and West in financing small as well as large enterprises.

Aside from foreign capital there are always the interesting possibilities inherent in the fact that the Eastern countries, while poor in goods and material evidences of wealth, have large reserves of gold and silver. Eastern purchases of the two noble metals have long been great factors in fixing demand for them. Unfortunately, the metals shipped to the Far East go out of circulation. Either they are buried or, in the form of ornaments, they are worn by the women of the family. The amount that is made up into jewelry is so large that it is no wonder that running away with another man's wife is a serious offense in the East. One banker in Peking over a period of two months in 1920, traced $15,000,000 worth of silver into one Chinese province and an outflow through the same period of less than $3,000,000. Another province in ten years absorbed over $150,000,000 and exported only a minor fraction of that amount. This silver does not, to any large degree, enter trade nor is any credit structure built upon it. This is a condition general in the Far East. One of the most striking and significant features of the building and growth of the Tata Iron and Steel works in India was the fact that it was financed by the Indians. For almost the first time a large native constituency was brought together which saw that investing money in industry is not sacrificing it, that capital is valuable for use as well as possession. If Eastern peoples can be brought generally

to a realization of this fact, the East is abundantly able to finance its own development.

For many years it has been customary for economists and supposed economists periodically to harrow the feelings and destroy all sense of security among western manufacturers by dilating upon the "teeming millions of the East" who, with their low standard of living were just about to cut the ground out from under Western industries. This basic theme has been occasionally elaborated by reference to the fact that even the small daily wage demanded by the Oriental laborer is paid in silver and not in gold. Fine-sounding warnings that we should have a care lest "the yellow man with the white dollar beat the white man with the yellow dollar" have reverberated through space. Much, indeed of the "yellow peril" talk that has produced so much international discord is based upon the idea that Oriental labor, because wages are low, is cheap, and that it constitutes a danger to the industrial security of the Western workers. Mining men, being accustomed to work in many countries with many sorts of labor, have long since learned that low-priced labor is not necessarily cheap. As to mines, at least, other conditions are usually more important than the nominal rate of wages, and workmen who receive small pay are generally worth no more than they are paid.

While individuals of the various races may measure up to the highest standards of labor efficiency, it is rarely possible to recruit a whole working force in the countries of low wages equal in producing capacity to the same number of workers recruited in the countries of higher wages and better working conditions. When the cost of extra supervision, extra housing, larger plant, slower speed, and other factors which go with "cheap" labor is taken into account, the gain is usually much less than appeared probable when the original estimates were made. There are many reasons for this, and not the least important is the deterioration that white labor itself undergoes when in contact with the colored. Standards of efficiency go down rapidly and a feeling of caste promptly springs up which prevents the white man from doing the work to which he is accustomed

at home. Even the crudest mechanic assumes the position of a boss and requires a native to do all the hard work. Since the white men as officers and supervisors set the pace for all, the final effect of this spirit is reflected in the cost sheet. Japanese have found that the same rule obtains in Korea, where at first Japanese and Koreans were employed side by side. The Japanese workmen promptly assumed the position of superiors and attempted to make the Koreans do all the work. As a result mixing labor is now discouraged there, and the railways are even displacing Japanese foremen by trained Koreans.

It is also to be remembered that with each set of workmen a certain rate of speed will be most economical. It is entirely possible that with Chinese this may be less than with American workmen, and accordingly a higher capital cost for equipment must be faced. There is some reason to believe this is so. Properly organized, trained and directed, however, Asiatic labor is capable of giving good results, as witness the operating costs at the Suan mine of the Seoul Mining Co., $3.95 per ton and those of the Oriental Consolidated, also at Korea, $3.09. There are no metal mines in China which permit a direct comparison, but in the collieries it requires from six to nine times as many men as in American mines to produce the same output. In part this is due to differences in mining methods, especially the large use of explosives and machines in American mines, but to a large degree it merely reflects the fact that low wages require employment of more men in order to get the same work done.

The efficiency of labor depends on many factors; the strength and endurance of the men; their food and housing; brain power and mental attitude toward the work; their experience and training for the particular job; their organization and direction.

As regards the first of these factors, the strength and endurance of the individual workers, the general verdict of observers would be favorable to the Chinese, though there are virtually no accurate statistics available and there are facts which indicate that physically the Chinese workman has been over-estimated. Life insurance companies, it is

true, refuse to sell straight insurance to any Chinese unless they live under foreign conditions as to food and housing and employ a foreign doctor. They do, however, sell all other forms of insurance on exactly the same terms as to foreigners resident in the East; that is, at an advance of about 5 percent over home rates. They consider that the acquired immunity of the Chinese to filth diseases offsets any greater risk and they use the same mortality tables for Chinese and foreigners alike. Indeed the Chinese are counted as being slightly better risks than foreigners resident in the East because of their more temperate habits. In one particular there is a marked difference: The insurance companies will not take Chinese except those of prominence and assured position because of the danger from fraud and substitution of bodies. The moral risks therefore of insuring in China are assessed by the companies as greater than the physical, though apparently information is too incomplete for the companies to feel safe in writing insurance except with the added chance of profit incident to investment policies.

Foreign officers experienced in training Chinese soldiers are generally enthusiastic as to their qualities. General J. W. N. Munthe, who has had wide experience with them, comments particularly on their good eyesight, absence of nerves, amenability to discipline, and ability to stand strain. He estimates the average weight not more than 140 pounds and remarked that the men are usually slighter in build than American or European troops. There is the same difference in China as elsewhere between men of the north and men of the south, where the average is physically smaller. Chinese troops, according to General Munthe's experience, while not so strong as European, show more endurance. They may not work as rapidly but they will stand more hours without going to pieces and will outmarch any troops of which he has records.

In any estimate of the working power of a people, large allowance must be made for the effect of food and housing. Judged by standards obtaining in Europe and America, both are radically defective in China and the Far East generally. Contrary to frequent assumption it is not that food is in-

sufficient in quantity, but it is its character that would be criticized. In Chinese villages the people seem to be always eating, and a group of carriers will stow away an enormous amount of provender at a sitting and in surprisingly short time. The food varies in different parts of the country, but it is almost exclusively vegetable and includes an unusual amount of greens and numerous articles not eaten elsewhere. Even the fats are mostly derived from vegetable oils; and pork, chicken and duck are the only meats widely eaten, though the Mohammedan Chinese substitute mutton for pork. Baking is virtually unknown. Ordinary bread is made usually of coarse native flour. It is usually cooked by steam and looks like a raw doughnut, but fried bread is also common. Baked bread is usually eaten only on joyful occasions, three or four times a year. Food is either boiled, steamed, or fried, and in order to economize in fuel it is largely prepared in public restaurants from which it is bought directly or from street hawkers. Meals at all hours is the rule of the country and regular feeding is the exception. Food is prepared under most unsanitary conditions and quantities of raw vegetables and fruits are eaten in season despite the universal pollution of the soil. Since it is not customary for large enterprises to feed their employees, systematic studies of Chinese food and rations seem not to have been made. So far as general observation goes the ordinary coolie ration would seem to rank low. Shantung coolies working at the Fushun mines near Mukden in 1917 were stated to eat millet, pork, onions and similar food so cheap that they could maintain themselves for 7 to 8 sen (3½ to 4 cents gold) per day and the coal company only charged 10 sen (5 cents gold) per day for boarders at the company hotel. In the southern part of China rice instead of millet forms the main element in the daily ration. In the Chinese army the allowance is 75 catties, equal to 100 pounds, of rice per man a month.

In South Africa when the Kaffirs come to the mine compounds they have been living usually on food similar to that used in China, except that they use less grain and drink milk. The Chinese use virtually no milk, butter or cheese, but consume grain and vegetable oils freely. Before the

Kaffirs can stand regular mine work they must be given nearly 30 days of systematic feeding, with a ration containing nearly 4,000 calories. It seems reasonable to assume that some similar attention paid to feeding Chinese would result in improving them as laborers as has proved true in other countries. Furnishing the food itself and requiring it to be eaten on the premises proved in Ecuador a satisfactory way of meeting the same difficulties as would promptly appear in China—the disposition to gamble away excess or pass it on to innumerable relatives and dependents. In ranch work in California, systematic feeding has brought Hindoos up to the same standard of labor output as competent white workmen. The best locomotive does poor work when the fire box is filled with dirty rather than clean coal or is left half empty of any fuel, and a workman needs at least as much consideration as a machine.

Left to their own initiative Chinese workmen are content with extremely poor houses. They build of brick or stone and use lime mortar of poor grade. The bricks are only slightly burned, if at all, and a severe rain often results in much damage to the house. The floor is earth, brick, or stone, the roof is tile or clay, such windows as are present are lattice covered with paper, and the ill-fitting door swings on wooden hinges. The house is poorly lighted and is ventilated by chance. There are few bathing facilities and water is drawn from running streams, shallow wells or surface pools which usually are badly contaminated. Artificial heat is reduced to the minimum and in winter the family depends upon using wadded cotton garments to keep warm. Workmen's houses are very dirty and full of smells. Kitchen, bed, and everything else are in one room and clothes are not changed day or night. It would seem clear that the physical surroundings of the ordinary workman are not such as to preserve or increase his working power. In addition there is the fact that his quarters are crowded, often with people not altogether congenial, and there is no quiet and privacy such as makes for recovery from fatigue. Chinese seem to be able to do with little sleep and also to sleep at any time and place, which is fortunate since there seem to be no hours when a Chinese village is quiet and

few when even an individual household is unanimous in the purpose to sleep.

Recital of these conditions at once raises the question to a foreigner as to why the Chinese endure them. The answer lies in their mental attitude, which is after all the greatest difficulty in the way of new industries. Broadly speaking, the Chinese do not insist on better food and housing because they consider what they have good enough. Material things do not loom as large among the wants of the Chinese as of the Americans. There are other things they want more. More boy babies, the excitement of gambling, the maintenance of the family bond, "face" and similar matters appear to them much more important. It must be remembered that in China the social unit has long been the family and not the individual. What a man earns must be shared with all relatives who make claim on him. If a man has a better or more convenient house it will shortly be overflowing with poor relatives, so why improve the house? If he sets a better table, the number to be fed will increase until of necessity the ration is reduced to the average.

This community of interest influences workmen in another way. Despite the general poverty and the small variety of industries, it is difficult to enforce discipline by discharging unsatisfactory workmen. This involves no great penalty on the man discharged, since he simply goes to live with some relatives until he finds another place, and he need be in no hurry finding it. If dismissals become too frequent there is always the danger of a strike, and in China, if strikes and boycotts are short-lived, they are also unanimous. So close knit is the social organization that none dares stand out alone and there is no dissenting minority when the time for action comes. These conditions are changing and the individual is beginning to stand out from the mass but the change is slow and has not yet gone far.

China is not a country where savings have accumulated to form wealth comparable to that of Western countries, though in the aggregate a good many million ounces of silver are hoarded in the country. The great majority of the people live so hand-to-mouth that they cannot be inde-

pendent of the will of their immediate associates. At the same time they have come to accept this situation as one which cannot or need not be changed. Chinese have quite as much preference for "white collar" jobs as have Americans but they accept much more generally the fact that there are not enough of such jobs to go around. In many particulars China is a democracy. A man may rise to the highest position in life, but few men do so and the vast majority have not only no notion of attempting it but make little effort even to better their daily lot. Saving a competence appears out of the question to most, and aside from acquirement of a fortune through politics or some lucky gamble it seems seldom to enter the calculations of the people. It is not that the coolies' job is liked, it is merely accepted.

However possible it may be for a man to rise from the position of coolie, he must bear the brunt of the hardest labor and the strictest social discrimination so long as he is in that position. Whether born to a higher class or risen to it, he will go to great extremes to avoid the loss of "face" involved in doing "coolie" work. For example, it is difficult to train Chinese students thoroughly in engineering because even carrying the surveying tape involves loss of "face" and more than one instructor has found his students' results wrong because they would leave to the coolie all such lowly work. At first glance it would seem that the high social premium placed on position would operate to stimulate men to larger earnings. Mere possession of wealth, however, brings no credit. The possessor must live the life of a gentleman of leisure to be received at the higher rating. So long as possession of a good income requires continued labor it has no sufficient attractions. As a result possibly of centuries of brigandage and government founded on the principle of tribute, security of accumulations has been so slight and the avenues for investment so few that the accumulated wealth of China is not large in proportion to its population.

While estimates of the mental ability of another people are never more than personal judgments, I would follow unhesitatingly those who consider the Chinese intellectually

fully the equals of other people. They merely fail to use these powers effectively from our particular point of view. The social organization has been such that they have had no sufficient incentive to accumulate property. Millions of Chinese work and work hard. Too hard, if one may judge from observation. The common coolie handling goods with carrying pole or wheelbarrow probably works regularly beyond his strength, and many become wrecks. He only works, however, to get a bare sufficiency to eat and a shelter of some sort for himself and family. As soon as possible he quits, and whenever he has any temporary surplus he gambles if possible. Meanwhile over him is a vast pyramid of people who do little or no work. They live on their wits and on the coolies. This, of course, is not entirely true. There are Chinese contractors, merchants, bankers, and others who contribute to social welfare as in other countries, but the number of men who manage to attach themselves to each "white-collar" job is striking. Every bit of such work is parceled out among as many as possible. An American banker found that it took eight Chinese clerks to do the work done by one in the United States, and the greatest ingenuity is shown in inventing reasons for attaching one more person to any payroll.

The difficulty here is not with the individuals, but with the plan of organization that obtains. The fault, from the point of view of production, is that it does not stimulate the individual to greater efforts. Chinese excuse this on the basis that the great economic pressure on the individual makes failure so disastrous that he must merge himself in a larger unit, such as family or guild, for protection. Owing to this clan organization it is difficult to mix workmen from various provinces. A Shantung foreman has a poor chance to succeed with Hupei laborers, and the reverse would be equally true. Nepotism is widespread and seldom condemned. It is regarded as a man's duty to favor his relatives and to provide each with a place if possible. Every great man is surrounded with a crowd of hangers-on for whom he must provide in times of adversity and for whom he makes places on the slightest opportunity. To a considerable extent this relation holds right down to the lowest

man in any organization having authority to hire and fire. The bond which holds together any working force is external to it and independent of the standard of efficiency shown by the men.

Failure to regard the individual seems to have worked here as in other lands toward a decrease in efficiency and a low production per worker. With the same number of individuals and a smaller amount of goods produced, clearly there are fewer goods for each. This in turn reacts on the poorest and enormously stimulates the effort to advance by short cuts through thievery and sharp practice. It also makes those who by merit, good fortune, birth, or any other means, have risen above the rank of hand workers hold most tenaciously to their rights and privileges. Until the individual worker receives some direct return from increased effort, notable improvement in efficiency would not seem likely.

The most common form of organization of labor in China is through contractors and sub-contractors and it is by contracting that a Chinese workman most frequently rises. The contractor binds his men to him by a system of cash advances which keep them perpetually in debt, toward which the universal habit of gambling is a powerful influence. There is an elaborate system of squeezes and commissions on both wages and supplies and these hidden profits are often the most important incentive for taking the contract. While many Chinese contractors are scrupulous in performance of agreements, it is not safe to accept the widely-advertised dictum that Chinese are always faithful in such matters any more than other people are. Examination of consular records shows the wreck of many enterprises founded on contracts with Chinese, and in practice it is customary to exact bonds and guarantees to an extent not known elsewhere. Complaint is also common among the Chinese as well as foreign employers that Chinese contractors show much adroitness in catching employers at a disadvantage and then by an artifically created labor shortage or other means forcing a change of terms. The contract system makes it easy for a foreigner to do business in China as long as he is content to do it on the contractor's terms.

If he has his own ideas as to times, seasons, speed of work, and similar matters, he will have great difficulties.

Chinese have had little training or experience to fit them for work in modern mines. The great bulk of the population is engaged in farming. In the winter the men from the farms go to the towns and work as wheelbarrow or carrying coolies. At such times, labor around the mines is abundant. At other times it is not always easy to keep a full force. The men are widely trained in hand crafts such as the ordinary building trades, but their standards are low both as to quality of work and rate of output. Only the immediate cash expenditure is considered. From that point of view much of the work is cheap, but it is often poorly and slowly done. In a modern saw-mill at Shanghai, Chinese working under an American foreman get about one-half the proper duty out of each machine. Chinese hand workers manage to do with absurdly crude and poor tools and it is not altogether surprising that they have become widely indifferent to accuracy. It is extremely difficult to get a Chinese carpenter to make anything exactly square or a brick mason to lay a true wall. If an object be "about" as specified it satisfies his sense of the degree of exactness required and this runs through Chinese industry generally. To standardize production is therefore most difficult, despite the well-known cleverness of Chinese workmen in exact reproduction from a model. Few have received training with modern power tools and unfortunately many of those so trained have the methods of twenty to forty years ago. The number of instructors available has always been small in proportion to the work to be done and with the inherent conservatism of the Chinese it is not surprising that the work has never been speeded up. The men who first got training as machinists jealously guard the field as their own. Cantonese who got their hold nearly fifty years ago at Tangshan still monopolize employment in the shops of the Kailan Mining Administration in Chihli.

It is extremely difficult to get Chinese workmen to care properly for machinery. An engine driver will often fail to report repairs needed on a locomotive, under the impression, apparently, that in doing so he gives valuable in-

formation for nothing. Chinese are so accustomed to living and working under general conditions of disrepair that the importance of tightening bolts in time does not appeal to them. So, too, while it is possible to get hoisting engineers for a mine, it does not seem possible to get rapid hoisting and generally speaking a man grand enough to run an engine of any kind is much too important to condescend to see that his engine is kept in good working condition.

It is difficult also to get men to work in close harmony in a shop as each tries if possible to force some other to pay him a "squeeze." Thus one Chinese employer had trouble with the men running an overhead crane, who would not handle pieces quickly and efficiently for the men on the floor below because the latter refused to pay "cumshaw." It did not matter that all were alike working for one company and that it was not a piece-work job. It was sufficient that one was in a position to retard or facilitate the other's work. There is a striking lack of any willingness to do something for nothing, save where the well-defined claims of family require it. These incidents point to deep-grained habits of mind and suggest some of the difficulties that lie in the way of developing modern industries in the country.

There are few miners, and probably any large mine force would need to be recruited from men wholly new to the work. This has some compensations since by temporarily increasing the number of supervisors it should be possible to train the men into right instead of wrong habits, though the difficulties arising out of lack of a common language are not to be underrated. As now conducted in China, mining is not especially cheap and the factor of tons per man, where it has been possible to obtain exact figures, is low. Judged by the test of experience the "cheap" wages of China do not materially lower production costs, while they do undoubtedly yield poorer results in quality of output and speed of production.

The railway system of China is as yet far from complete. About 6,500 miles of line are in operation. In addition there are many lines projected and for much of this additional mileage franchises have been granted or promised

to various nations. As is well known, the railways so far built and most of those planned have been designed not alone to serve the economic needs of the country but also the political designs of the Powers. The railways already in operation were built almost entirely by foreign companies or under foreign supervision and usually the major profit was in the sale of material and in a percentage on construction costs. As a result, the roads have cost too much and there was for a long time no uniformity of construction or equipment.

The Chinese Government has been attempting to bring order out of this chaos and nominally at least all the important lines are now parts of the Chinese Government Railways. The gain in uniformity thus brought about has been largely offset by the poor standard of operating efficiency which the Government officials permit. Equipment is not only heterogeneous and light, but car distribution goes by favor. Since under the operating system in vogue the station master has large powers, it is often necessary to pay him regular bribes to insure prompt despatch of goods, and on payment of a "cumshaw" favors as to classification and weight are granted. In fact, there is no scheme unearthed by the muck-rakers who ventilated conditions on American railroads twenty years ago which has not been in regular operation in China recently, though it is to be remembered that for years the country has been plagued by civil wars, and conditions faced by the operating officials can hardly be taken as having been normal or inherent. Service is frequently interrupted by track difficulties, and recently has been disturbed by political disorders. Despite formidable numbers of troops and special railway guards, petty stealing of goods in transit is so feared that it has for some years been customary to send coolies as guards with important shipments. With their beds and food these men take their position in or on top of the car of freight they are to guard, and are supposed not to leave the car until it reaches its destination. They form a picturesque feature of Chinese trains. Incidentally, they frequently go to sleep while smoking and set the goods and the train on fire. Along some lines there are regular companies

which will furnish coolie guards and insure delivery of goods for a fee.

Chinese railways derive large revenue from passenger traffic, while freight is scanty. Rates, however, are generally fair and even low. The open coal rate, for example, is one cent Chinese per ton mile, which is below present American standards. There are also special rates. Various coal-mining companies have agreements that the rate on coal from their collieries shall always be less by a certain amount than the rate from any competing mine and in other ways special properties are favored. Handling costs are small, transfer of coal from narrow-gauge to standard-gauge cars, done by hand, amounts to 1¼ to 1½ cents (gold) per ton. Likin, or transit dues, while irregular and annoying, are by no means always burdensome. For two small shipments valued at $175 going about 400 miles and crossing a provincial line, the total likin was $3.40 and the freight $11.05, all in Chinese currency in 1917. Rates have since increased. Large companies having a steady output, such as a colliery, usually arrange to commute likin by a small annual lump-sum payment.

Many of the defects and annoyances characterizing railway traffic in China are incident to present political conditions and the fact that the whole system is new and incomplete. It may be anticipated that there will be steady improvement, and at the worst the burden thrown on industry is not greater than that met by pioneers in other countries at a similar stage in development. The railway system presumably will grow rapidly when the country again becomes settled. There are already two main north-south lines as far as the Yangtze, with an east-west line from Mukden through Tientsin and Peking to some distance beyond Kalgan. Connection between Hankow and Canton lacks but little, and the Belgians built an important link in their projected east-west trunk line through the center of the country even during the War. The great plain of China should soon be served by a fair number of lines, while from each of the important seaports railways are reaching out into the interior. The plateau and mountain country of the west is almost untouched by railways

though the French have built and operate a line to Yunnan-fu.

It is in the western country and the more mountainous districts of the south that any considerable mines other than those of coal and iron may be expected to be found. The country, however, is sparsely settled, not well adapted to the style of agriculture with which Chinese are familiar, and offers few certain attractions to a traffic manager. The conditions are not parallel to those which led to building the transcontinental railways of the United States and Canada, since in those countries there was something to build to. The Pacific afforded an outlet at the other end and the Pacific states offered a field for building up big industrial centers. Lines pushed across China to Turkestan or Tibet, on the contrary, would not only encounter great physical difficulties, but would offer no reasonable expectation of dense or balanced traffic after they were built. The roads would find their main excuse in strategic considerations; and China is not in a position to build on this basis, as shown by the inhibition, now fortunately withdrawn, on extending the line from Kalgan across Mongolia, a project that has much to commend it.

China is fortunate in the possession of a number of rivers that are important avenues of transport. These are all in use, and in addition a large number of canals and every small stream that can float any sort of boat has been put to service. An extremely complete system of water transport has been built up and even remote villages are reached at some season by some sort of boats. The main artery is the Yangtze, up which there is regular traffic the year round as far as Hankow (595 miles), to which point moderately large ocean-going steamers can also travel about half the year. In summer, boats drawing 28 to 29 feet can reach Hankow, but in winter, 8 feet is the controlling depth of the channel. From Hankow, smaller river steamers drawing 5 to 6 feet go to Changsha and Ichang most of the year, though occasionally interrupted in the winter for a few weeks. Vessels drawing 8 feet can run part of the year to Changsha and those requiring up to 14 feet can reach Ichang in summer. Above Ichang a steam tow-

ing service part of the year is maintained to Chungking by boats drawing 3 feet, but the bulk of the traffic is handled by native junks. A few shallow draft steamers operate on this part of the river. It is generally believed that with proper designing and care in operation a river service of value can be maintained for most of the year. On the Min river, one of the largest in Szechuan, the bulk of the trade is carried in flat-bottomed junks drawing less than two feet. On the Siang-kiang, in Hunan, boats drawing but one foot of water are in use, and to bring coal out from Paoching flat scows are built which are run as far as Hankow on the Yangtze and there broken up for lumber, much as the early settlers on the Ohio carried their produce to New Orleans. The possibilities of such traffic are distinctly limited. At Paoching it is seasonal only and the period of high water is so short that the traffic becomes in effect an annual episode. It would be literally impossible to accommodate on the surface of the river, within the time water is available, enough boats to carry the output of a modern colliery, assuming it were possible to meet the other problems of production and seasonal storage.

Wherever one goes in China water transportation is seen, but brief studies show that little of it is adapted to modern industrial needs. When the Pekin Syndicate opened the Jamieson Collieries in Honan, the Tao Ching railway was built to give access to a system of rivers and canal by which coal could be transported to Tientsin and so to the sea. The company expended both time and effort in developing transport by this route, but without satisfaction. The slowness, irregularity, and uncertainty of the method are all against it. The native contractors wait for a return cargo and so consume as much as two months on a trip. As time is not greatly valued by the Chinese this does not worry them, but it is another matter to a colliery manager attempting to move cargo regularly and without too heavy investment in equipment. When the Chung Hsing mines were modernized, a short railway line was built to the Grand Canal in order to deliver coal to Yangtze ports. Since the coming of the Tientsin Pukow railway, the line built by the company has been a white elephant,

for the through railway route proves not only more expeditious but cheaper.

It is to be remembered that the canals of China are old and small. Even the Grand Canal, while large, is not modern and is chronically in disrepair. It is also fairly crusted over with "old customs" that increase the expense of shipping. It seems probable that at comparatively small expense the canal could be made an avenue of transport of real value, but the larger part of the canals and minor streams of China are of no value save for carrying farm produce to local markets and other similar uses to which they have been put for centuries. While in this description only a few of the rivers and canals have been discussed in detail, it should be understood that the general conditions are similar in both north and south China. Aside, therefore, from parts of the large rivers, the Grand Canal, and a few shorter artificial channels, it is not wise to count on inland water transport when establishing any industry that requires the handling of large tonnages.

Aside from the few railways and the water transport already discussed, the only means of transport is by carrier, and occasionally by pack-train in the south, and by wheelbarrow, pack-train, or cart in the north. There are virtually no roads and no system of reservation for roads. Indeed the track over which traffic moves is treated as private property and naturally the land-owner, whose acreage is certain to be small for his needs at best, begrudges every foot taken from his crop area. Even in regions where carts are used, travel is along mere tracks or trails across the fields. There are bridges made of stone and dating from centuries ago, but many of them are seriously out of repair and streams must be crossed by fords or crude ferries. Of the great system of stone-paved Imperial roads which once bound the country together, only traces remain, and cross country travel is usually along footpaths winding through the fields or deep-worn cart tracks, a mass of ruts and dust in summer and a sea of mud in winter. In Manchuria and Mongolia, there is a considerable cart traffic, but toward the south the cart is first supplemented by the wheelbarrow and then by car-

riers. Surveys and estimates have been made for individual roads in various parts of China, but always the project has been blocked and motors are as yet only used within the limits of cities and on a few routes.

The price of transport varies enormously with the region, season, character of the goods, and character of the trail. Despite the small wages paid and the limited investment in equipment, it is not cheap. In northern Honan in winter, when labor was available and the roads frozen, transport of coal 25 miles mainly by wheelbarrow, but in part by cart, figured out to about 15 cents (gold) per ton-mile. W. F. Collins gives figures for wheelbarrow transport of coal in Shantung that work back to 18 cents (gold) per ton-mile. In Kiangsi transport of limestone by carrier seven miles over fair trail and with a regular organization, cost 20 cents (gold) per ton mile. Transport of tin in South China by pack animals up to distances of 25 miles costs about 30 cents (gold) per ton mile. These figures perhaps make sufficiently clear the burden under which industry in China labors and why the larger part of the trade is local.

In considering establishment of any industry in China, it is necessary not only to take into account the usual fundamentals, materials, markets, labor, and transport, but certain other matters peculiar to China or in regard to which the circumstances are so exceptional as to be almost unique. The laws governing commerce and industry are like those nowhere else, but in addition to the peculiarities of the Chinese code there are the complications incident to the extra-territorial system, each national remaining under the laws and legal jurisdiction of his own country when on the defensive. It has already been agreed in the Washington treaty that this system shall be abolished, but how rapidly and what new system will take its place is still unknown. Meanwhile and practically, business has been conducted on the basis of mutual confidence reënforced by personal bond, to a most unusual extent. It follows that there are few countries in which the value of a good name is as high as in China. Business has long been conducted virtually on honor, and to the credit of both Chinese and foreigners

it may be said that enormous amounts of business are so conducted.

Credits in China afford the basis for much argument. Equally old and experienced foreigners resident in the country will maintain to you that Chinese are never to be trusted and that they may always be trusted. This is confusing, but on a par with the general contradictoriness of life in China that has been noticed by nearly all who have written about the country. The facts seem to be that the Chinese are much like the inhabitants of other countries and include both trustworthy and untrustworthy individuals. It is also true here as elsewhere that peculiar ethical values are attached to particular acts. The Chinese have a fine sense of the importance of living up to a deliberately given word, though they are not above attempting to enforce a novel interpretation of a contract if it be to their advantage, as happens elsewhere. They are not litigious and are accustomed to arbitrate or to pay rather than to go to law. The best tribute to their ideas of honesty is probably the fact that virtually all business done with them by foreigners is based on personal bond, not on collateral, as is customary elsewhere.

The Chinese, as is true of other peoples not familiar with the details of modern large-scale business, entirely under-estimate the value of skill, organization, and experience in developing a new industry. They also frequently fail to discriminate between gross and net returns and it is widely customary to pay dividends at a fixed rate regardless of earnings. The Chinese business world is not accustomed to limited liability. Each shareholder is a partner and his liability is without limit. Having in view the quality of human nature engaged in trade it is not surprising that one hears of firms where each partner has his own lock on the company safe, which can only be opened in the presence of all.

The lack of real authority of a central government, now so striking, is by no means merely an incident of the present. The Chinese have not had for centuries any central government that was not imposed on them by the will of a conqueror, and not unnaturally they yield to it what they must

rather than whole-heartedly. In practice, it has often happened that despite agreements with Peking, profitable business could not be conducted until local Chinese had been satisfied. When the Chinese Engineering and Mining Company offended local Chinese public opinion, the Lanchow Company was financed and run at a loss as a rival until the older concern came to terms. Since the two joined to form the Kailan Mining Administration the closest harmony has prevailed and the business was satisfactory until interrupted by the civil wars. The Pekin Syndicate had a similar experience with native mines prior to joining them in formation of the Fu Chung corporation, a selling company for both. Numerous other instances might be cited. The moral is that any large business in China must have the good-will of the people of the community just as similar business must in any other land.

Another difficulty to be met in China is that due to differences in exchange. China uses silver for currency in place of gold and within a year the purchasing power in China of the American dollar has been known to decrease or to increase by more than one-half. So large a change is unusual but increases and decreases of 30 percent have been frequent. This may work to the advantage or the disadvantage of a company at any one time. In the long run, together with the chaotic condition of local currency, it forms a tax on industry, since a large number of banks and exchange houses make their whole profits out of these variations. This is too large a subject for discussion here.

New industries in China can only be successfully developed if established deliberately and on adequate scale after thorough study. It is no country for taking a flyer in expectation of quick returns. In view of the character of the labor, its lack of training, and the peculiar laws and business customs, a successful enterprise requires high-class management and will necessitate for some years an unusual amount of supervision. This in turn means a large overhead which must be distributed over a considerable volume of output to insure success. If one such enterprise be founded large enough to warrant maintenance of a first-class staff, there is every reason to believe that around it may be collected in

time a number of smaller profitable businesses. This has been the experience of all the older and successful houses in China, and it is a constant cause of surprise to find the multitude of directions in which houses have profitably expanded that began as important export merchants, ship owners, or in some other of the lines of industry that first brought foreigners to China.

CHAPTER IX

WHAT OF THE FUTURE?

THE problem of the Far East is, in what direction, how far, and at what speed its peoples will change the character of their industrial and social structure. It is not a question whether the so-called "unchanging East" will remain unchanged—the East is already changing. It never was unchanging. The thought of it as such arose from the circumstance that the peoples of the East made their major advances along the path of civilization earlier than did those of the West and they reached the period when, under their conditions of life, the law of diminishing returns came into play at a time when the Westerners, under other conditions, were still in the period of acceleration. Races change slowly, but at times whole nations change their wants, their satisfactions, and their form of organization for obtaining these satisfactions, with surprising rapidity. In the last half century, as quick communications have brought the peoples of the East and the West into closer contact, there has been much more of a tendency for the Easterners to adopt the manners and methods of the West than for the reverse to take place. At times and in particular countries there has been a quick and widespread change in the outward appearance at least of the civilization of Eastern countries. Is this to become general? Will this current influence the whole or only a small part of the people of the countries concerned? Is the change to be rapid and general or slow and erratic? All these are questions of first importance both to the East and the West.

If the vast populations of the Trans-Pacific countries are going to change over, wholesale and promptly, to the style of living of Western peoples, if they are going to want the things we want and to strive for them by the same or similar methods, this is probably the most important and significant fact either the Orient or the Occident has now

to face. Such a change would mean an enormous increase in the demand for many goods and, in turn, this would be reflected in a corresponding draft upon the world's supply of raw materials. Such an increased demand will be much less important if the countries affected are themselves in position to supply these raw materials than if they must, to any considerable extent, trench upon the sources now open to the rest of us. The latter would give rise to competition on a scale heretofore unexampled. This possible competition for raw materials is a matter of first importance in trade relations; it may also become, as the world has come recently to realize, a grave source of danger in political relations and a powerful incentive toward war.

The suggested potential increase in demand for the raw materials of industry is especially significant in connection with minerals. It is the generous use of minerals that has permitted the Western peoples to alter so markedly their mode of living from that of their ancestors. In their disposition toward increased consumption of minerals, even the more highly industrialized Western countries show as yet no marked tendency toward slackening. Minerals are not reproducible. To a large extent they are consumed in use. Only to a limited extent is it possible by salvage to build up a permanent stock. The mines are wasting assets. If the great populations of the East are to consume as much iron, copper, lead, zinc, and other metals per capita as do now those of the leading Western countries, there may well not be enough to go around. It is substantially certain there is not enough to supply any such demand if the supply must come from present known sources. Control of supply and distribution is, therefore, a most important matter as regards both peace and war. Neither can a large varied industrial civilization be maintained in peace, nor a long war be fought to successful conclusion, without an adequate supply of minerals.

It is possible in theory at least for a country not possessed of mineral wealth but rich in other resources, to obtain its supply of fuels and metals by purchase. Indeed, this is actually done, strikingly in the case of Argentina and to a considerable degree by Italy and France. None of

these countries, however, shows the highest per capita consumption of any of the common metals and all are handicapped by their poverty of mineral resources. In an earlier chapter it was shown that a deficiency of the minerals of which a large tonnage is needed, such as coal and iron, is a more serious matter than in case of those of which a few ounces or pounds is sufficient. In any event, to buy one must have something to sell, and if the East is to become a large consumer of Western goods, it must develop an exportable surplus of its own products to balance its imports.

The survey that has been made indicates clearly that the Far Eastern countries are characterized by deficiency in mineral resources rather than by abundance. A few striking exceptions occur. Of tin, tungsten, and antimony the Eastern countries have a surplus that is of world importance. The Malay States, with Siam, the Netherlands East Indies, and China are now able to dominate the world's trade in these metals and, while some falling off is to be expected as the rich surface placers of tin and tungsten are exhausted, the Eastern countries may be expected to continue to occupy an important, if not the chief place in the trade in these minerals. A rough general idea of the value of these exports may be obtained from the following table in which the total production of Far Eastern countries for the year 1925 is valued at average New York prices for the year. Not all the output was sold in New York and no account is here taken of the necessary deductions for cost of shipment and selling, profit of traders, import duties, and many other items that would need to be subtracted in order to obtain the value at the port of export. Nevertheless, the total as a yard-stick for measuring the trade that might be held in balance is clearly not large when compared with world trade standards.

LEADING FAR EASTERN MINERAL EXPORTS IN 1925

(Valued at New York Prices)

Tin	$120,860,800
Tungsten	5,326,800
Antimony	771,400
TOTAL	$126,959,000

These three represent, as already indicated, the major contributions of the Far East to the exportable surplus of the world trade in minerals. Japan ships copper and various of the other countries send out these and other minerals; but all are likely to find need at home for what they now export and, as already indicated, must in addition, import large quantities of non-ferrous metals if the local per capita consumption ever approximates that of the West.

In the matter of fuels, the situation is somewhat different and this is important since with a suitable supply of fuel to furnish energy an industrious and ingenious people may turn to manufacturing and trading even if certain raw materials need to be imported in quantity. Petroleum is found from Siberia to the Netherlands East Indies, as has been shown by Mr. Heroy in the chapter he has contributed to this book. Japan, China, Indo-China, Siam and the Malay States seem certain not to produce petroleum in amounts beyond local needs. Exploration in the Philippine Islands is incomplete and has so far been discouraging, but a definite statement is not yet possible. Sakhalin and the Netherlands East Indies are both likely to make important contributions to the world's supply.

Coal is the most important of the minerals from many points of view and in this book considerable space has been devoted to consideration of the character, distribution, and extent of the coal reserves of the various countries. This survey has taken into account that present production affords no valid criterion for measuring what would be possible in event of a general industrialization of the people and a resulting demand on the coal mines. The only country in the Orient containing coal fields of world importance is China. The others, with the possible exception of Indo-China, either are now or may be expected to become importers of coal, especially if they undergo any major industrialization. A number of estimates have been made of the amount of coal in reserve in the Chinese coal fields and these have already been reviewed. The first general summary was made in 1913 by N. F. Drake for the International Geological Congress. Drake considered the probable coal reserve to be of the order of 996,612 million

tons. The last authoritative general statement that has been published was that of W. H. Wong, the Director of the Geological Survey of China, who, writing in 1924, estimated the actual reserve at 23,435 million tons but considered that taking account of very thin beds and mining to greater depth, a possible 40,000 or 50,000 million tons might be estimated. As Wong has said, this would supply China for 2,000 years at her present rate of consumption, but would only be adequate for 70 years for the consumption of the United States at its annual rate. It would last about 16 years if the per capita rate of consumption of the United States were applied to the population of China. If, however, Drake's estimate be accepted, the fields could supply the present American market for 1,465 years or could supply the population of China at the American per capita rate of consumption 346 years. For comparison, it may be stated that the estimated coal reserve of the United States is 3,838,657 million tons, an amount equal to 5,800 years' supply at the present rate of consumption.

The other countries of the Far East are much less well supplied with coal and, as is true throughout the world, coking coal—which is indispensable to any large metallurgical industry—is even more scarce. So far as is known, the Eastern countries must depend upon China for any supply of metallurgical fuel. Japan, the most highly industrialized country in the East, has some 8000 million tons of coal, equivalent to about 150 tons per capita. This would last about 300 years at the present per capita rate of consumption, or 25 years on the American per capita basis. In addition, Japan controls much of the coal of Manchuria, but in the long run the people living in that country would need to be taken into account in estimating the years through which it could be supplied to Japan.

As to iron ore, the deficiency faced by the Far East is even more striking, and this is all the more important when account is taken of the vital necessity of steel in quantity to support any such type of civilization as obtains in the Western countries. The details as to reserves and production have already been given. It will be sufficient here to point out that, aside from the lateritic ores of the Philip-

pines and the Netherlands East Indies, to be more specifically discussed later, the largest known or probable reserves lie in China. These have been found on careful examination to be very much less than had long been believed. Accepting without question the largest figures given by F. R. Tegengren as a result of the study made by him for the Geological Survey of China, the per capita reserve of possible iron ore is about 2 tons. This may be contrasted with 670 tons, the corresponding figure for the United States. If, however, the figures for accepted or actual reserves be used, China may be credited with 0.92 tons per capita and the United States with 37.9 tons. The present rate of consumption of iron ore in the United States, domestic and imported, is about 0.7 tons. Accordingly, the actual reserve of China would last the Chinese less than 2 years on the American basis of per capita consumption; the possible reserve would last nearly 3 years. The Japanese per capita reserve is 1.5 tons, taking as a basis the possible ore. This would, at the American rate of per capita consumption, last Japan a trifle more than two years.

In the Philippine Islands and in the Netherlands East Indies are considerable bodies of iron ore of the type found on the north shore of Cuba, which in recent years has been used in American sea-coast furnaces. It lies well situated for mining and, while exploration is as yet not complete, there is enough data to warrant the statement that several hundred million tons are present. The ore is not of the best type for furnace use and requires preliminary treatment, mainly driving off the contained water, before it can be used. The methods of beneficiating it are well known and it can be cheaply produced. In neither country is any large supply of coal suitable for making metallurgical coke known, indeed in the Philippines the amount of coal of any kind known to be present is extremely limited. In the Netherlands East Indies, an experimental plant is now being erected, designed to produce iron from the lateritic ore by direct reduction and melting in an electric furnace. Such a technology has been worked out, but there are no data now available that warrant belief that it can supplant blast-furnace work on the basis of cost and efficiency save in

limited and restricted fields. Accordingly, any major development based upon use of the Philippine ores, and to a less degree of certainty on those farther south, must be predicated upon combining them with Chinese or Japanese coal. It is a general rule of trade that because of the relative tonnages involved, iron ore moves to coal rather than the reverse; so shipments of ore from the Philippines to the north may be expected if and when these reserves are brought into production and any steel-making center based on these ores is likely to be in China or Japan. Such shipments of iron ore would facilitate development of industry in the Philippines, since the natural back freight movement would be of coal, of which the Islands are now considerable importers.

Without reviewing in detail the evidence given in the various antecedent chapters the general conclusion may be stated that the Far Eastern countries do not contain such supplies of mineral resources as will permit the development of an industrial system according to Western standards. If this change is brought about in any considerable degree, it must be on the basis of minerals or mineral products imported from other parts of the world.

No attempt need be made here to discuss the larger question whether it is necessary or desirable that the Far East should follow the West along the path of industrialization, or even whether it will do so. The answer to such questions lies in the psychology of peoples and is outside the scope of this study. Present concern is only with the problem of whether or not the Far East contains the resources, and particularly the exhaustible mineral resources, to support such an industrialization of its people in the event that a wholesale change in that direction be attempted. This is a question of fact, and to it the correct answer is undoubtedly an unqualified negative.

Despite the circumstance that no adequate data are available for answering the other questions suggested and involved, a few facts and inferences to be drawn from them may be mentioned. The first is the unquestionable fact that despite all the difficulties involved the Far East is taking on more and more of the outward aspects of a Western in-

dustrial civilization; modern steamers ply her seas and rivers, one may travel many thousand miles in speed and comfort along well built railways; petroleum has widely replaced vegetable oils as an illuminant and is in turn being supplanted by electricity; an extensive net-work of telegraph lines already exists and telephone and radio systems are rapidly expanding; newspapers are everywhere and motion pictures nearly as widely distributed; schools in which Western knowledge is placed before the pupils may be found in mountain villages farthest back from the sea in most of the countries; everywhere Western ideas have penetrated and Western material comforts and conveniences are following. It can hardly be doubted that to a greater or less extent the people coming into contact with them will desire them in increasing quantities and will set out to possess themselves of them so far as their means may permit. A Chinese Tuchun may entertain philosophic doubts as to democracy and be entirely blind as to the saving grace of primary elections, but he does not hesitate to commandeer a sleeping-car on the railway. A coolie may know or care little about voting, but he shows no disinclination to journey on a steamer or to enjoy the films. Undoubtedly a transition is actually under way. It remains to be seen how far and how deep the change will extend. It is by no means necessary that the East should forsake entirely its philosophy of life in order to appreciate and enjoy the comfort of living Westerners have brought about through lavish use of material. The practical problem is, what has the East out of which to build for itself a similar material civilization or to exchange with the West for what it lacks? Granted that the supply of mineral resources, on the whole, is disappointing, what remains?

In the first place, a word of caution is necessary. Even if the mineral supply is small as compared with that available in the West, it is not unimportant either for this or the next or next succeeding generation. It is to be expected that any transformation of industry that may occur will take place gradually and that the load thrown upon production will in no case immediately come to a maximum. It is also hardly to be anticipated that the whole population of any

country will change its habits and needs in a single generation and for us the most important matters center around the present and the next half century. The comparisons that have so far been made have been with countries using minerals most freely. Others are also worth considering. It is interesting to set down in parallel, for example, not only China and the United States, but Japan and Italy, confining attention to area, population [1] and per capita reserves of the most important minerals.

COMPARISON OF CHINA AND UNITED STATES

	Area (*Square Miles*)	*Population* (*Millions*)	*Population* (*Density*)	*Coal Reserve* (*Tons per*	*Iron Reserve* *Capita*)
China	4,278,352	427.68	100	2,330 [2]	2
United States	3,743,529	112.0	30	34,274	670

COMPARISON OF JAPAN AND ITALY

Japan	149,793	55.96	373	150	1.5
Italy	119,733	38.9	324	5	0.2

These comparisons make it clear that while, as contrasted with the United States, the leading countries of the Far East are deficient in the main source of mechanical energy and the leading structural material, neither is badly supplied as compared with Italy, a country that has managed to play a large and important part in world affairs and continues to do so. Italy's statesmen recognize her poverty of resources in proportion to population, and there is the usual division of opinion as to whether this condition is to be remedied by acquiring richer territory, using force if need be, or by securing raw materials through peaceful trade. Fortunately, modern Italy has so far followed the latter course and has grown and is growing increasingly prosperous as a result.

The eastern countries, particularly China, have an advantage over such European nations as Italy in coal supply and it has already been shown that coal is the largest modern source of energy. By setting to work the coal of any country the output of goods may be multiplied without

1 Figures from Statistical Abstract of United States, 1924.
2 Using Drake's estimate of reserves; Wong's estimate would give 94 tons per capita.

making corresponding drafts on food supply, and that is the road to wealth.

The problems of food supply in the East are too numerous and varied for discussion here. They are being made the subject of further study by one of the conference groups of the Council on Foreign Relations. It may be recalled that much of China is mountainous. The same is true of Japan, the Philippines, and of the Orient generally. The civilization of the East, however, is dominantly based on grain culture, to which only the smaller part of the land is adapted. There is little doubt that in other forms of agriculture adapted to rough land, and in an expansion of animal husbandry, so far retarded by widely current Buddhistic philosophy, there lie opportunities for increasing materially the food supply. It is even probable that changes in laws and customs may make it possible to increase the output of staple foods, such as rice, in China. It is undoubted that drainage and irrigation offer means of increasing the area of cultivable land, and in the great prairie plains of Manchuria and Mongolia there are extensive areas where agriculture may replace pasturage and still leave opportunity for a large animal population on the farms, just as it has done in the prairie states of our own Middle West. Difficult as problems of food supply admittedly are in countries of dense population and limited resources, they are not insoluble, and much light may be thrown on them by a careful study of the engineering possibilities of the incompletely developed portions of the Far East.

It remains to consider the possibilities of manufacturing in the Orient, and here an increasing amount of information is becoming available. With large industrious populations, as in China and Japan, and with an important if not unlimited supply of coal, it is clearly possible under stable social conditions, to manufacture a considerable amount and variety of goods even in the absence of an abundant supply of minerals. Machinery for doing so, or the metals out of which it may be made, must largely be imported. Steamers and railway supplies, or again the raw materials entering into them, must also be imported. The railways themselves, lacking the large tonnage of mineral freight which

form the backbone of American railway traffic, must be organized and operated on a system somewhat different from our own. If the choice be made of the newer form of transport, hard roads and motor cars, the cars, and probably in the main the fuel to drive them, must come from abroad. Italy has shown that it is not necessary to bring in the actual cars, for Italy, by affording one of the world's great markets for scrap iron and steel, has become an important center for the manufacture of motor cars, electrical machinery, and similar products, in which the maker retains the profit from converting a cheap raw material into a valuable device or product. This path is open to Japan, China, and the Far East generally. A beginning has been made. Japan imports pig iron and China already affords a good market for scrap iron. The manufacture of Mazda lamps in Japan is merely one of many illustrations that might be cited as to the possibilities in the Far East.

Products of wide range are now manufactured from raw material obtained from the sea or from the animal and vegetable kingdom, and a number require only non-metallic minerals which happen to be present in abundance. Many of these goods can be made in the East whenever the Easterners set their wills to it and organize their energies and resources to that end. Many are now being made on an increasing scale. The following list, taken from the China Year Book, from among goods now being manufactured in China from domestic or imported materials, is highly suggestive.

MANUFACTURING INDUSTRIES IN CHINA.

Albumen factories.
Arsenals.
Asbestos works.
Bone dust plants.
Button factories.
Canneries and food preserving establishments.
Carpet and rug factories.
Cement mills.
Cloisonné and enamel works.
Chemical and dye works (indigo, paint, lactic acid, general chemicals).
Cotton spinning and weaving mills.
Distilleries, breweries, and mineral water bottling plants.
Dockyards, shipyards and engineering works.
Electric power and light plants.
Flour mills.

MANUFACTURING INDUSTRIES IN CHINA.—(*Continued*)

Furniture factories (especially reed and wicker).
Gas works.
Glass making plants.
Grass cloth factories.
Knitting works.
Leather manufactories and tanneries.
Marble and stone cutting yards.
Mats and matting weavers.
Match factories.
Nail and needle factories.
Oil mills and beancake presses.
Palm leaf fan works.
Paper mills.
Piano, organ and musical instrument making.
Porcelain and enamel works.
Printing and lithographing plants.
Railway repair shops.
Rice hulling and cleaning mills.
Rope walks.
Rubber manufacturing plants.
Saw mills.
Silk filatures and weaving mills.
Soap and candle making.
Tea cleaning and packing.
Sugar refineries.
Tobacco manufacturing.
Woolen works.

In addition there are mines and smelters, as already discussed, various services such as the railways and tramways are maintained, and numerous minor or exceptional industries are to be found. It is clear that some of these, especially heavy manufacturing industries, have little opportunity for expansion save on the basis of imported material. Others, such as those based upon fibers, may grow rapidly and to great size if conditions favor. Whether or not, and to what extent, this can and will be brought about, is a consideration that leads far from the field of fact and into the interesting but highly speculative domain of how far our Eastern neighbors will change their habits of thought.

Will China, for example, establish a government or governments that will police the country without stifling industry by extortion? Will the people learn to value quality and uniformity of product sufficiently to permit standardized manufacture? Will they come to have such mutual confidence as will permit pooling of capital through corporations or some other device? Will the Easterners

and the Westerners learn that the price of industry is peace and will they mutually bear and forbear? On the answer to those questions rests the decision of the main question as to what is to be the future of our relations with Trans-Pacific countries.

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INDEX

D

E

F

G

H

S

T

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